AGRICULTURAL ENGINEERING

AUGUST · 1948

THE JOURNAL OF THE AMERICAN SOCIETY OF AGRICULTURAL ENGINEERS

Air-Power
Spares Horsepower
Grinds More Per Man Hour

● It is no trick to get grain or forage into a hammer mill and reduce it to particles of desired size. The engineering problem is to get it out of the grinding chamber before repeated contact with the hammers has made some of the material too fine, caused more or less heating, and wasted power in the process.

Case hammer mills save substantial amounts of power in the grinding chamber by using sufficient power at the fan to pull ground material promptly through the screen. Less obvious but similarly significant are the relations between linear and angular velocities at the grinding circle, also the space relations among the hammers and with the screen.

Fast grinding of tough grain or forage calls for keen edges. Case hammer tips have eight edges; you loosen a bolt and turn a new edge into position. Sharp edges, clean scavenging, and good geometry in the grinding chamber—these are reasons for the fast, cool, relatively uniform grinding of Case hammer mills.

Designed for fast work with the power of farm tractors, these mills hold down power cost per bushel. More important, they grind more bushels per man-hour, push upward the final yield per man which is the essence of productivity and prosperity in agriculture. J. I. Case Co., Racine, Wis.

CASE

AGRICULTURAL ENGINEERING

Established 1920

CONTENTS FOR AUGUST, 1948

Vol. 29, No. 8

AGRICULTURAL ENGINEERING is owned, edited, and published monthly by the American Society of Agricultural Engineers. The editorial, subscription and advertising departments are at the executive office of the Society, Saint Joseph, Michigan.

SUBSCRIPTION PRICE: $3.00 a year, plus an extra postage charge to all countries to which the second-class postage rate does not apply; to A.S.A.E. members anywhere, $2.00 a year. Single copies (current), 30 cents each.

POST OFFICE ENTRY: Entered as second-class matter, October 28, 1933, at the post office at Benton Harbor, Michigan, under the Act of August 24, 1912. Additional entry at St. Joseph, Michigan. Acceptance for mailing at the special rate of postage provided for in Section 1103, Act of October 3, 1917, authorized August 11, 1921.

AGRICULTURAL ENGINEERING is a member of the Audit Bureau of Circulations.

RAYMOND OLNEY
Editor and Business Manager

EDITORIAL

Specialization Within Agricultural Engineering

BROAD interests and intensive specialization in engineering activities are competitive desirable opposites calling for continual compromise and balance. The point of optimum breadth of interest and intensity of specialization, within human capacity, seldom stands out clearly.

A recent engineering study of one engineering society has indicated that specialization, as developed and encouraged in its technical divisions, is endangering the loyalty of its members to the over-all organization, and the unity of the group in its professional field.

This suggests reconsideration of the agricultural engineering field, as to its essential unity, the common interests of its separate technologies, and the degrees of specialization favorable to most effective advancement of those technologies.

Agriculture provides an ample basis for unity among agricultural engineers. Its engineering problems have proven adequate in volume, range, and distinctive character to warrant differentiation from engineering as applied in other industries.

In addition to their common objective and beneficiary, the basic fields of technical specialization in agricultural engineering are closely related in application. Soil and water engineering measures are carried out by machines and structures, and often by application of electric power. Farm machinery, in addition to being used in soil and water engineering, is used in and around farm buildings, stored in farm buildings, and often advantageously powered by electricity. The engineering brotherhood of technology and purpose is further evident between farm structures and rural electrification, with wiring and appliances increasingly becoming integral parts of farm structures, and structures a major subject for electrification. Thus each technical branch of agricultural engineering has a strong basis of common interest with every other basic technology of the field.

The strength and appeal of specialization is in the concentration on dominating individual interests which it permits; the opportunity it provides for mastery, accomplishment, and recognition in a small but tangible segment of engineering science and art; the efficiency with which the specialist can determine the extent to which his specialty is applicable to any outlined problem or project, and with which he can proceed to apply it where applicable.

Individuals vary widely in their capacities to specialize intensively without losing their sense of proportion as to the importance of their specialty, its relation to the world outside of their self-imposed boundaries, its dependence on other specialties and on less specialized leadership, their need of working with and understanding others to make their specialization most fruitful in knowledge or material progress. The critical point in specialization, for the individual or group, is that beyond which its effective yield stops increasing and begins to diminish.

It seems that most agricultural engineers will find it to their advantage to retain a general interest and practical knowledge in at least one field of agricultural engineering technology outside of their particular specialty, even at the possible expense of limiting their immediate progress in that specialty.

Many will go further, and while specializing in one field or another will exert themselves to keep reasonably well informed in all branches of agricultural engineering, and will maintain at least a speaking acquaintance with other branches of engineering, agricultural science, general business, community activities, and some substantial dirt farmers. They will prove a strong source of unity and leadership in agricultural engineering and the American Society of Agricultural Engineers.

The colleges and some other public service organizations already provide a favorable environment for contacts and cooperation between various specialists. The ASAE can help steer its younger members away from excessive narrowing specialization with joint sessions of its technical divisions at Society meetings, strong general sessions, and attention to all branches of the field in its section meeting programs.

In some of the industries devoted to the manufacture and sale of field machines, building materials, or electrical equipment, it may be more difficult for the agricultural engineer to avoid excessive specialization while filling his place in the engineering production line. With recognition of the problem, and the cooperation of older agricultural engineers in helping him to make new and broadening contacts, it can be done. It is a phase of personnel development which should prove profitable to the employers as well as to individuals concerned.

Whenever the question may arise it will be well to remember one point. An engineer or group of engineers can unconsciously drift toward increased specialization, but it takes diligent conscious effort to develop the breadth of interest and understanding necessary to provide, coordinate, and capitalize on most of the work of highly specialized engineers or technicians. There can also be conscious, well-planned, and well-directed specialization by individuals with appropriate aptitudes, within the framework of broad objectives; without the individual specialist losing sight of the relationship between his work and that of others; and with minimum danger of agricultural engineers losing their group strength and identity.

Investments and Water Supplies

IN increasing areas water supply is becoming the critical factor resisting the expansive pressure of population, agriculture, and other industries. Water can no longer be taken for granted as one of the abundant, inexhaustible resources.

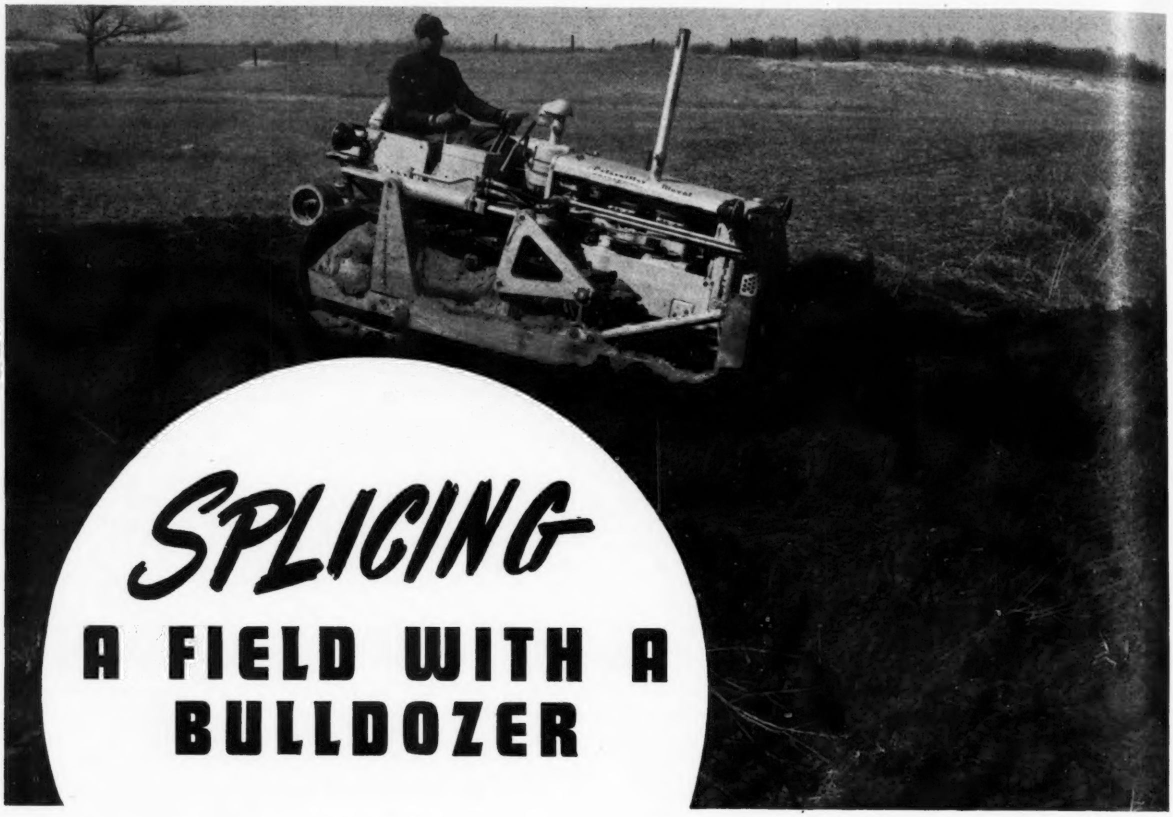
Temporary overabundance of surface water, due to seasonal and unusual weather, only anticipates the dry side of the average. Ground water, if less subject to seasonal variations, is not an ocean, but literally a pool or series of pools with definite limited proportions, storage capacities, and replacement rates. Their water supply for practical purposes can be exhausted. Homes and other investments dry up along with water sources.

The race for water rights, for more and deeper wells, and for investment without thought of future water supply is not an engineering answer to the problem. Excessive pressure on the water supply in these problem areas can only be diverted by widespread knowledge of the quantity and quality of water normally available; the current use, loss, and supply hazard factors; and the increasing unit cost of conserving more of the supply or increasing the supply by borrowing from other watersheds.

Even with current advances in scientific rainmaking, the day seems quite distant when the flying farmer may find it physically, economically, and legally feasible to send a plane to the seashore, stake a claim to water rights in a landward-bound cloud, herd it to his farm, and milk it for needed precipitation. The prospect of getting substantial water supplies by other means of condensation from the air seems equally remote.

Until such time as these distant possibilities may materialize, the only sound basis for investment in homes, farms, and other water-using activities in dry areas will be more and better engineering information on watersheds and ground water storages, as to annual water supply, quality, storage capacity, current and prospective use demands, controls and established rights, losses, possibilities of diverting water from other watersheds, and per gallon and acre-inch costs of various means of conserving or increasing the water supply.

The whole future of some watersheds will depend largely on what engineers can do, within practical limits of cost, about the water supply. Investors in these areas, who wish to maintain and improve their positions as investors, will do well to recognize this fact.



AGRICULTURAL ENGINEERING

VOL. 29 AUGUST, 1948 No. 8

Improved Designs for Farm Grain Bin Floors

By Gordon L. Nelson

Member A.S.A.E.

SAFE storage of grain in farm bins calls for floors designed and built to carry unusually heavy loads and help protect the grain from rodents, insects, and moisture. Rodent damage to farm-stored grain is responsible for an estimated annual loss of from four to five per cent of the value of the grain. Ratproof foundation and floor construction would prevent much of this damage. Experimental wheat storage bins[1*] at Jamestown, N. D., and Hutchinson, Kans., have shown that faulty floor design could result in wheat spoilage as high as 1,716 lb due to moisture on the floor of a 1000-bu bin. Weaknesses in bin floor design often promote structural damage or failure of the bin superstructure. Suspended floors sagging under heavy loads of grain may weaken the entire bin. Some prefabricated bins of metal and other materials are very subject to wind damage when empty, unless well anchored to a substantial base[2]. Anchorage details are an important feature of the floor design for such bins.

Concrete is frequently recommended[2,3] for bin floor construction because of its durability against structural deterioration and resistance to attack by rodents and insects. The part which concrete plays in ratproofing farm grain storage has been well publicized. Less attention has been given to concrete floors as a factor in controlling insect damage to stored grain in Oklahoma and other grain-growing areas where mild winters promote insect infestations.

A common source of infestation is from insects harbored in grain and dust accumulated in floor cracks or spaces in the walls[4,5]. The larva of the cadelle, a serious grain pest, finds harborage by boring into wooden portions of the bin, making disinfection difficult. The rice weevil, one of the most destructive grain pests in Oklahoma, is able to fly from infested grain to newly stored grain if it can gain access through the floor or other parts of the bin. Meal worms thrive in accumulations of grain in contact with damp wooden flooring and may burrow into the floor, causing severe damage to the structure. A bin floor that is impenetrable by insects and smooth and free of cracks and crevices should help control insect damage. Such a floor could be readily cleaned and disinfected before new grain is placed in storage. Concrete bin floors have these characteristics, but have been criticized because of dampness. This can be largely remedied by designs which take into account the effects of excess moisture and the ways it may enter the bin at the floor level.

A moisture content of 13 or 14 per cent is generally considered to be the upper limit for safe farm storage of wheat[2,6]. A greater moisture content may lead to molding and increased respiration. A chain of cause and effect is thus established wherein the molding and respiration produce heat, which further increases respiration and mold growth. It is apparent that, if the bin floor is only slightly damp, damage may extend beyond the grain in contact with the floor.

Another effect of moisture is related to the reproduction of insects which infest stored grain. Fenton and Whitehead[4] state that serious infestations may develop if the moisture content is above 14 per cent. Recent data[7] indicate that a moisture content of 11 per cent or lower may be necessary to prevent reproduction of the rice weevil at temperatures between 70 and 85F (degrees Fahrenheit). An infestation may start from a few insects. As their numbers increase, their bodies release heat and moisture which further aggravate storage problems. Whitehead[8] has shown that infestations may arise near the floor in shallow bins. He sampled wheat from eleven farm bins in Oklahoma during 1941. Fig. 1, taken from his report, indicates that although insects occur in greater numbers in the upper portions of a shallow bin, they are quite numerous at the floor level, where dampness could promote insect damage.

Two common types of farm grain storages are (1) the ordinary farm granary with a single or double row of rectangular bins, generally varying in width from 8 to 12 ft, and (2) the prefabricated circular metal grain bin. Floor designs for each of these are discussed under separate headings.

Floors for Farm Granaries. Concrete slab-on-fill floor construction is common for this type of storage. However, unless special precautions are taken to install a waterproof membrane in the floor and place a deep, well-compacted porous fill before the floor is cast, capillary moisture rising through the slab from the ground beneath may lead to grain spoilage and increased insect activity. Furthermore, floors for farm granaries are often built at a level of 1½ to 2 ft or more above grade to place the floor at a convenient height for truck or wagon and eliminate the possibility of flooding by surface water. Such an elevation would require a large amount of fill

This paper was presented at the winter meeting of the American Society of Agricultural Engineers at Chicago, Ill., December, 1947, as a contribution of the Farm Structures Division.

GORDON L. NELSON is associate professor of agricultural engineering, Oklahoma A. & M. College, Stillwater, Okla. (Formerly senior agricultural engineer, Portland Cement Assn.)

*Superscript numbers refer to appended references.

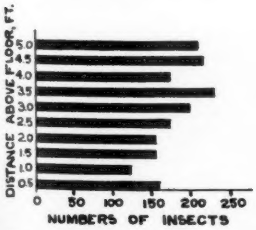


Fig. 1 Average distribution of grain insects in 11 Oklahoma farm grain bins sampled by Whitehead[8]. Numbers of insects shown are based on a 1000-g sample from each 6-in depth interval

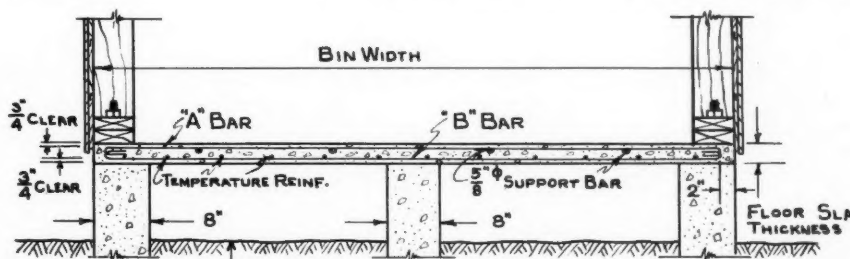


Fig. 2 Typical cross section through a suspended grain bin floor of reinforced concrete

preparatory to casting a slab-on-fill type of floor; and unless the fill is carefully and thoroughly tamped, uneven settlement may result in structural damage to the floor. Where the granary site is uneven, additional grading and filling would be required. Suspended bin floor construction with reinforced concrete would help overcome these difficulties and result in economy of labor and materials through elimination of fill. Such a floor could be built at any desired height above grade to insure dryness and take advantage of gravity for emptying the bins.

A cross section of a suspended grain bin floor of reinforced concrete is shown in Fig. 2. Fig. 3 shows a similar floor for an experimental granary under construction at the University of Missouri under the direction of J. C. Wooley. A center support is provided to reduce stresses in the slab. The bearing walls may be built either of concrete block or cast-in-place concrete. Design data for suspended floors for three bin widths and three grain depths for each width are presented in Table 1. This table is applicable within the limits of bin widths and grain depths shown for any type of grain and common wall construction.

It may be of interest to describe the analysis and assumptions on which the designs in Table 1 are based. Janssen[9] has developed a formula for calculating the weight of grain carried by bin walls, and by a simple transformation it will give the total weight carried by the floor (see appendix). This formula is widely used in the design of walls for all types of grain storage structures, and experiments have shown that it gives a close approximation to the total load carried by the floor. However, Janssen's formula is developed on the assumption that vertical and horizontal pressures in the grain are uniform at all points on a horizontal plane. Ketchum[9] suggests that it would be more correct to assume pressures constant on the surface of a dome, giving non-uniform distribution of floor loads. This non-uniformity undoubtedly exists. It is unreasonable to assume that the force due to the upward reaction of the wall on the grain mass due to friction will be undiminished throughout the bin. Bovey[10] measured vertical pressures at the bottom of a timber crib bin 13.4 by 12.35 ft in cross section using three diaphragms located in the approximate positions indicated in Fig. 4. This diagram based on Bovey's data demonstrates that there is considerable reduction of vertical pressures near the bin walls. However, the published data cannot be used to establish a relation between grain depth and vertical pressures because it did not correlate these factors. The loading diagram, Fig. 5, shows one approach that might be used to give a uniformly varying distribution to loads calculated by Janssen's formula. The largest vertical load would occur with no friction between the grain and bin wall, i.e., a hydraulic type of loading W_2 in Fig. 5. The load intensity at the center of the bin was assumed to be halfway between W_1 and W_2, Fig. 5, since no data is available for a more precise estimate. This arbitrary assumption is confined within comparatively narrow limits, and as a result should give a close approximation to the actual load intensity. It is further assumed that the floor load decreases uniformly to the bin walls, with the total load being equal to that calculated by Janssen's formula. The uncertainty as to the distribution of the floor live load and the effect of other factors,

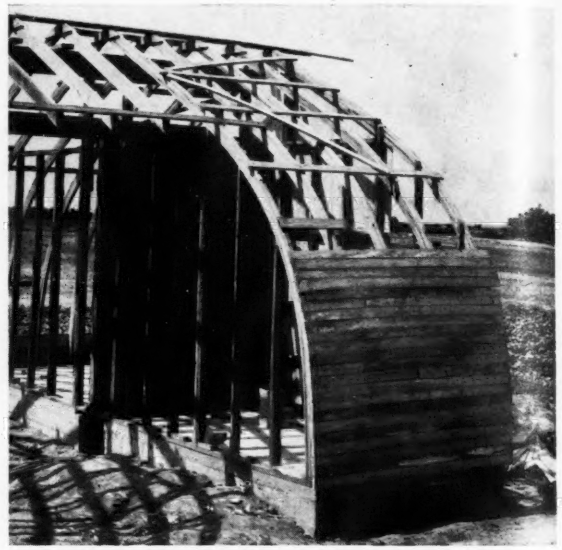


Fig. 3 Suspended floor of reinforced concrete for an experimental granary under construction at the University of Missouri. (Photo courtesy of J. C. Wooley)

such as emptying and filling, should be kept in mind when designing grain storage structures[11]. Actual observations of floor pressures on grain bins are needed to arrive at a more accurate estimation of floor loads. For grain depths of more than two and one-half to three times the bin width, Janssen's formula and experimental data show that the total load increases very little with grain depth. For these greater depths, a maximum load intensity arrived at as in Fig. 5 may be considerably larger than actually occurs. However the designs presented in Table 1 are for a maximum grain depth of 20 ft, with a minimum bin width of 8 ft, or a ratio of depth to width of 2.5.

Moment and shear diagrams for the type of loading proposed can be calculated by the area-moment method or other convenient analysis. Formulas for moment and shear at critical points in the floor slab are presented in the appendix. It is believed that improved distribution of reinforcement with a saving of steel is achieved by taking into account the non-uniform loading which very likely exists. Calculations show that the saving is in the order of 5 per cent, compared to designs for an equal total load uniformly distributed.

The magnitude of the design loads with grain of a given depth will depend on the bin wall construction and the characteristics of the grain, factors which are taken into account by coefficients in Janssen's formula. Values were chosen for these coefficients to give calculated live loads for the designs in Table 2 large enough for any grain and common type of bin wall construction. One choice of values was necessary for the product K times μ', and another for the hydraulic radius,

TABLE 1. REINFORCEMENT SCHEDULE FOR SUSPENDED CONCRETE GRAIN BIN FLOORS. REINFORCEMENT WEIGHTS SHOWN INCLUDE "A", "B", AND "C" BARS, TEMPERATURE REINFORCEMENT, AND ⅝-IN SUPPORT BARS. LENGTHS SHOWN ARE OUT-TO-OUT DISTANCES FOR HOOKED BARS. ALL BARS ARE ROUND CROSS SECTION.

			"A" bars,* ends hooked (Fig 6)		"B" bars,* ends hooked (Fig 6)		"C" bars,* ends hooked (Fig 6)		Temperature reinforcement**	
Bin width, ft	Floor thickness, in	Grain depth, ft	Spacing on centers, in	Length, ft and in	Spacing on centers, in	Length, ft and in	Spacing on centers, in	Length, ft and in	Spacing on centers, in	Reinforcement per foot of bin length, lb
		10	11½	7′8″	18	7′8″	11½	2′2″	8	12.2
8	4	15	9½	7′8″	14½	7′8″	9½	2′2″	8	13.5
		20	8	7′8″	12½	7′8″	8	2′2″	8	14.8
		10	8½	9′8″	10½	9′8″	8½	2′8″	8	17.7
10	4	15	6½	9′8″	8	9′8″	6½	2′8″	8	21.1
		20	5½	9′8″	6½	9′8″	5½	2′8″	8	24.0
		10	8	11′8″	8	11′8″	8	3′4″	6	23.6
12	5	15	6½	11′8″	6½	11′8″	6½	3′4″	6	27.1
		20	5½	11′8″	5½	11′8″	5½	3′4″	6	30.6

* Diameter of bars, ⅝ in

** Diameter of reinforcement, ¼ in

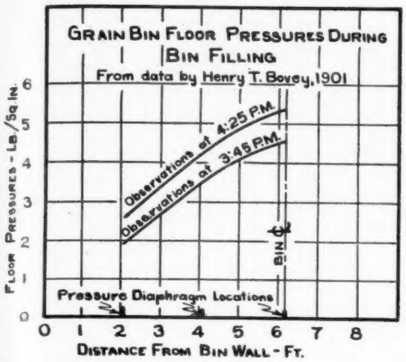


Fig. 4 Distribution of vertical pressures at the bottom of a 13.4x12.35-ft timber crib grain bin during filling

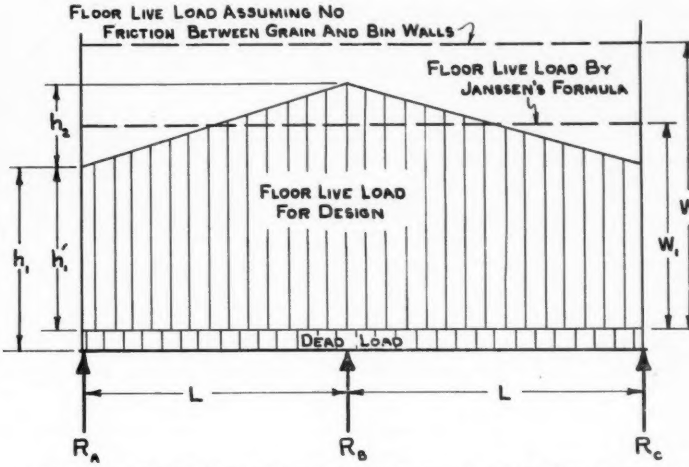


Fig. 5 Proposed grain bin floor live-load distribution. (Formulas given in appendix)

since the bin length is variable. The design data in Table 1 is based on $K\mu' = 0.20$; and a hydraulic radius of 3.50 ft for an 8-ft bin width, 4.25 ft for a 10-ft width, and 5.00 ft for a 12-ft width. These hydraulic radii give loads safe for any length up to 60 ft. The choice of the value of 0.20 for $K\mu'$ is based on experimental data, Table 2. These indicate that $K\mu'$

TABLE 2. REPRESENTATIVE VALUES OF "$K \times \mu'$" FOR JANSSEN'S FORMULA

(All values are for wheat. Superscripts denote source in appended list of references)

Wall Construction	$K \times \mu'$
Cribbed wooden bin[9]	0.252 to 0.270
Rough board bin[9]	0.247 (K=0.6 assumed)
Smooth board bin[9]	0.217 (K=0.6 assumed)
Tile or brick[9]	0.240 to 0.255
Concrete[9]	0.240 to 0.255
Steel cylinder, riveted[9]	0.219 to 0.285
Steel plate, horizontally corrugated[9]	0.281
Graylite board (Insulite)[14]	0.200
Unspecified[11]	0.250 (for general design purposes)

is generally higher than 0.20, even for smooth-walled bins. Since the floor load increases with a decrease in $K\mu'$, 0.20 was taken as a safe value. A weight of 49 lb per cu ft was taken for the grain.

Formulas for designing the reinforcement and depth of floor slab may be found in any appropriate handbook. Allowable stresses for the concrete and reinforcement are listed in the appendix. Those related to the quality of concrete are recommended by the American Concrete Institute[12] for concrete having a 28-day ultimate strength of 3000 lb per sq in. In the absence of preliminary tests of the materials to be used in making the concrete, the water-cement ratio for 3000-lb concrete should not exceed 6 gal per sack, including surface water carried by the aggregate. It is important to note that the designs in Table 2 are for 3000-lb or stronger concrete.

Figs. 6 and 7 show the manner of placing the reinforcement. Deformed bars should be used for all but the temperature steel. The reinforcement is detailed in accordance with recommendations of the American Concrete Institute[13]. Only two types of longitudinal reinforcement are required, since the "A" and "B" bars are identical. This feature simplifies placement, particularly for farm construction crews who may not be experienced in reinforced concrete construction. The accessories shown are usually supplied by the shop which furnishes the reinforcement. The slab bolsters and high chairs are necessary to space the reinforcement so that it will be protected by a ¾-in thickness of concrete. The "B" bars rest directly on the slab bolsters. The "A" and "C" bars rest on ⅝-in round support bars carried by high chairs. All reinforcement should be in position and wired together at frequent intervals before any concrete is placed. A layer of water-resistant building paper over the formwork, Figs. 6 and 7, will help make the formwork more watertight, especially if rough lumber has been used. The formwork supports should be spaced closely enough to prevent undue sagging under the weight of fresh concrete.

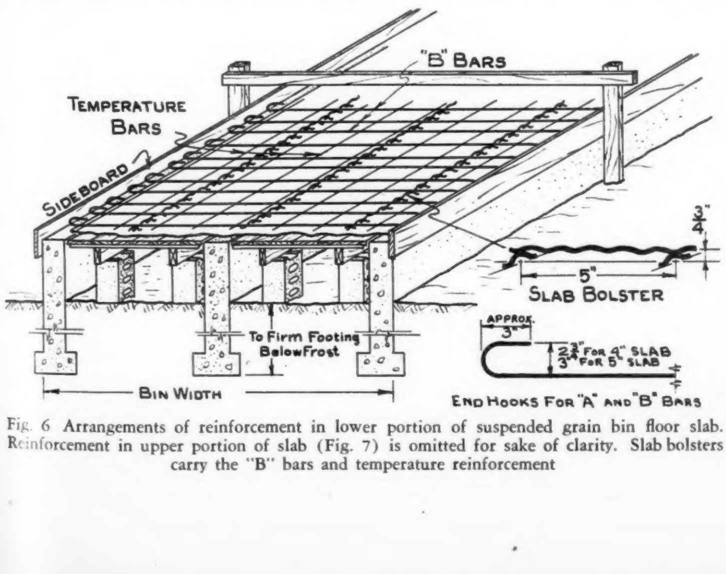


Fig. 6 Arrangements of reinforcement in lower portion of suspended grain bin floor slab. Reinforcement in upper portion of slab (Fig. 7) is omitted for sake of clarity. Slab bolsters carry the "B" bars and temperature reinforcement

Bases for Circular Metal Bins. Circular metal bins for grain and feed storage are in general use throughout the country. Manufacturers' recommendations for subfloor and foundation construction vary. At least one manufacturer recommends that the bin wall be supported on an unconsolidated ring of concrete blocks encircled with a wire band and laid with cores vertical for drainage. The subfloor recommended is a layer of sand or gravel overlain with the metal bin floor. Another manufacturer recommends that the bin be erected on a wooden platform equipped with skids to make the bin portable. The experimental sites[1] at Jamestown, N. D., and Hutchinson, Kans., demonstrated that subfloor construction is an important factor in controlling grain spoilage due to moisture in bins of this type. Stahl stated that the platform type of base with edges projecting beyond the walls almost invariably resulted in spoilage at the edges of the floor unless the floor-wall junction is specially shielded or drained. The

projecting edge provides a shelf on which moisture accumulates, then enters the bin beneath the wall. Calking is sometimes ineffective against moisture from this source.

Subflooring consisting of gravel or other types of well-drained fill encircled by an unconsolidated ring of concrete block for foundation would help prevent entry of moisture at the floor-wall junction, but under most farm conditions such construction might result in shortened bin life and lowered ability to protect the contents from insect and rodent damage. The foundation should be rigid and firm enough to preclude wall settlement or lateral movement which might cause wall joints to open or door frames to twist. The subfloor should provide firm, unyielding support for the metal bin floor to prevent damage or puncturing when empty; and should be impervious so that it will not offer a harbor for insects even though the metal floor deteriorates. Positive connection should be made between the floor and bin wall for anchorage.

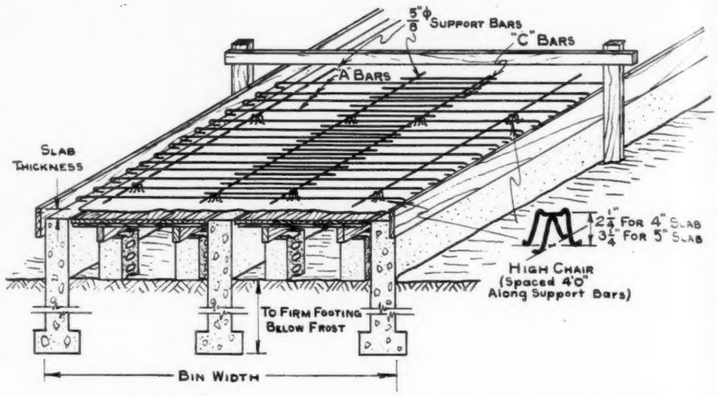


Fig. 7 Arrangement of reinforcement in upper portion of grain bin floor slab. "A" and "C" bars rest on support bars carried by high chairs. (See Fig. 6 for reinforcement in lower portion of slab)

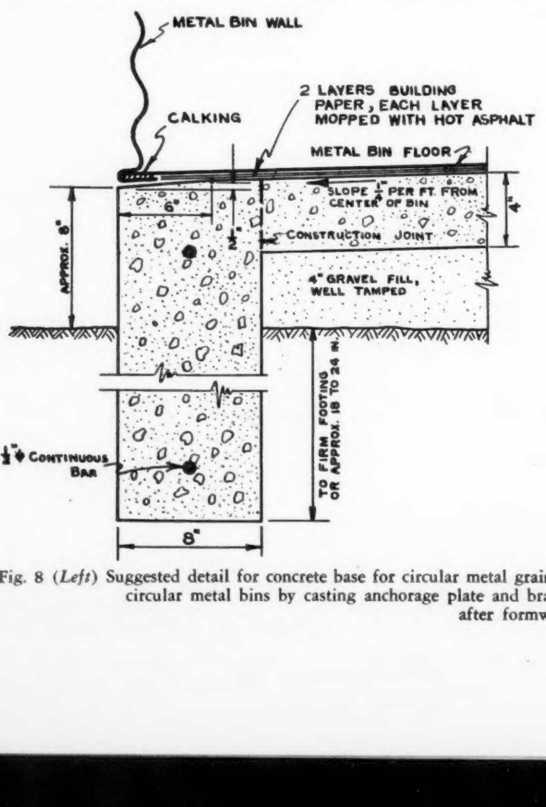
A concrete base including a slab on fill encircled by a curtain wall would help improve bin life and serviceability. A suspended type of floor might offer other advantages, but formwork construction and reinforcement would be difficult. Fig. 8 shows concrete construction which might be used without modifying lower edge details of the bin wall intended for other types of bases. The joint between the floor slab and curtain wall would allow independent movement of these two members without damaging the slab. In sites with unstable soils, the curtain wall should be reinforced with two ½-in round continuous bars. Anchorage for the bin should be provided by wires or other means. The concrete base should closely conform to the bin circumference, in order to eliminate a shelf beyond the bin walls. The subfloor is sloped from the center, with a sharp slope at the edge to provide positive drainage. As an additional precaution, calking might be inserted between the metal flooring and the lip at the lower edge of the wall. The waterproof membrane, consisting of asphalted building paper, together with the metal floor would prevent capillary moisture from reaching the grain. In the event the metal flooring deteriorates, the bin floor could readily be renewed by a 1½ or 2-in layer of concrete. This additional concrete would further seal the floor-wall junction against moisture.

Another improvement is suggested in Fig. 9 which involves alteration of the lower edge of the bin wall to provide a connection to the base. The steel plate, if cut and formed in sections to fit the bin circumference, could be used as a template in locating the formwork to cast a base flush with the wall. The metal plate could be temporarily bolted to the formwork, automatically positioning the anchor bolt and angle iron bracket before concrete is placed. After the concrete had hardened and the formwork had been removed, the waterproof membrane and metal bin floor could be placed, the nut on the anchor bolt tightened down, and lower ring of bin wall sheets bolted to the metal plate. This type of connection would provide positive anchorage for the bin, and shield the base from wall drainage.

APPENDIX

Janssen's Formula

$$w_1 = \frac{Wr}{k\mu'}\left(1 - E^{-Ky\mu'/r}\right)$$



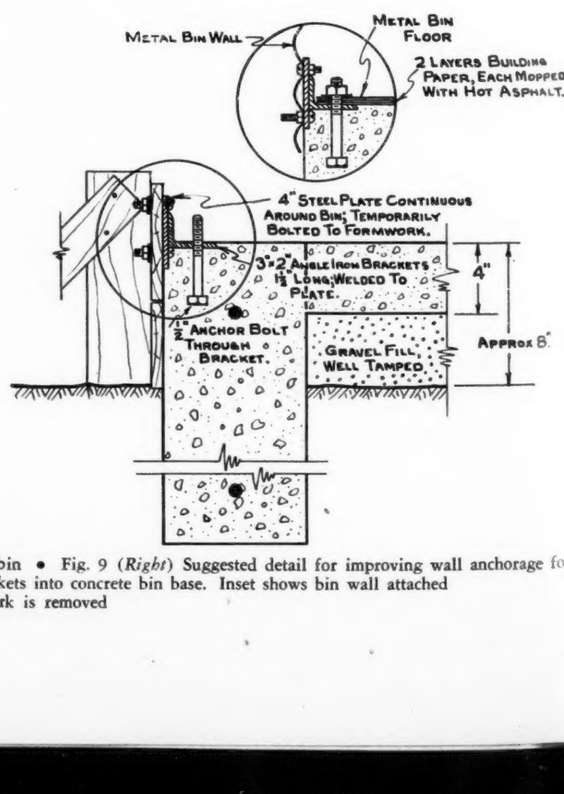


Fig. 8 (*Left*) Suggested detail for concrete base for circular metal grain bin • Fig. 9 (*Right*) Suggested detail for improving wall anchorage for circular metal bins by casting anchorage plate and brackets into concrete bin base. Inset shows bin wall attached after formwork is removed

where w_1 = grain live load on floor, lb per sq ft, uniformly distributed
W = wt of grain, lb per cu ft
r = bin hydraulic radius, ft
K = ratio of lateral to vertical pressure in grain
μ' = coefficient of friction, grain on bin walls
y = depth of grain, ft

Live load distribution, Fig. 5

$$b'_1 = \frac{3w_1 + w_2}{2}, \text{ lb per sq ft}$$

$$b_2 = w_2 - w_1, \text{ lb per sq ft}$$

where $w_2 = yW$, lb per sq ft

Reactions at supports, Fig. 5

$R_a = L\,(3/8\,b_1 + 1/10\,b_2)$ lb per linear ft of bin floor
$R_b = L\,(5/4\,b_1 + 4/5\,b_2)$ lb per linear ft of bin floor
L = clear span + depth of floor slab, ft
where $b_1 = b'_1$ + floor dead load, lb per sq ft

Internal moments

Maximum negative moment,
$M_b = L^2/8\,(b_1 + 8/15\,b_2)$ lb-ft per linear ft of bin floor

Maximum positive moment,

$$M_x = R_aX - \frac{b_1X^2}{2} - \frac{b_2X^3}{6L} \text{ lb-ft per linear ft of bin floor}$$

$$\text{where } X = L\left[\sqrt{\left(\frac{b_1}{b_2}\right)^2 + \frac{3b_1}{4b_2} + \frac{1}{5}} - \frac{b_1}{b_2}\right], \text{ ft}$$

Total shear at supports, Fig. 5

$V_a = R_a$, lb per linear ft of bin floor
$V_b = \frac{1}{2}R_b$, lb per linear ft of bin floor

Allowable unit stresses in concrete and steel

f_c, compressive unit stress in extreme fiber of concrete in flexure = 1350 lb per sq in
f_s, tensile unit stress in longitudinal reinforcement = 20,000 lb per sq in
v, shearing unit stress with special anchorage of longitudinal steel = 60 lb per sq in
u, bond stress for deformed bars = 150 lb per sq in

REFERENCES

1 Stahl, Benton M. Storage Performance of Grain Bin Floors. Agricultural Engineering, August, 1946.

2 Long, Thomas E., and Myron G. Cropsey. Grain Storage on the Farm. North Dakota Agr. Exp. Sta. Bul. 302, 1941.

3 Silver, James, W. E. Crouch, and M. C. Betts. Ratproofing Buildings and Premises. U. S. Dept. Agr. Farmers Bulletin No. 1638, 1930.

4 Fenton, F. A., and F. E. Whitehead. Control of Wheat Insects. Oklahoma Agr. Exp. Sta. Bul. B-275, 1944.

5 Swenk, Myron H., and Don B. Whelan. Control of Stored Grain Pests in Nebraska. Nebraska Agr. Exp. Sta. Circular 62, 1940.

6 Swanson, C. O., and F. C. Fenton. The Quality of Wheat As Affected by Farm Storage. Kansas Agr. Exp. Sta. Tech. Bul. 33, 1932.

7 Committee on Cooperative Research on Grain Storage in the Ever-Normal Granary. Progress Report No. 5, Aug., 1944 (unpublished).

8 Whitehead, F. E. Insect Populations of Farm Wheat Bins in Oklahoma and Experiments in Their Control. Proceedings of the Oklahoma Academy of Science, vol. 24, 1944.

9 Ketchum, Milo S. The Design of Walls, Bins, and Grain Elevators. 3rd edition, 1929, McGraw-Hill Book Company.

10 Bovey, Henry T. Experiments on Grain Pressures in Deep Bins and the Strength of Wooden Bins. Engr. News, July 14, 1904.

11 Long, J. D. Design of Grain Storage Structures. Agricultural Engineering, July, 1931.

12 American Concrete Institute Committee 318. Building Regulations for Reinforced Concrete. American Concrete Institute, 1945.

13 American Concrete Institute Committee 315. Proposed Manual of Standard Practice for Detailing Reinforced Concrete Structures. American Concrete Institute, 1946.

14 Amundsen, L. R. Determination of Band Stresses and Lateral Wheat Pressures for a Cylindrical Grain Bin. Agricultural Engineering, Aug., 1945.

Ag Engineering Research Problems

By Arthur W. Turner
FELLOW A.S.A.E.

IN THIS postwar period agriculture's research men are not looking backward; they are looking ahead at new problems that challenge the imagination. Let me list a few of the things now under consideration in agricultural engineering research.

1 What new equipment and changes in methods are needed in harvesting and curing hay? Dairy nutrition specialists say enough protein is now lost in handling hay to feed 7,500,000 dairy cows for six months. That indicates rather emphatically that methods now used in harvesting this valuable crop are awkward, inefficient, and antiquated. The development of new haying machines and procedures is largely an engineering problem.

2 What crop-conditioning requirements and facilities does the producer need so he can hold and market his commodities in top quality condition at his own convenience, rather than dump them on a flooded market at harvest time? This question opens up a whole field of engineering research that is relatively unexplored.

3 What are the economic factors involved in the production and decortication of new fiber crops, such as ramie, sansevieria, and others, on an industry basis? The present world shortage of fibers, which is especially serious in this country, indicates the pressing need to accelerate research that may lead to new fiber industries and establishment of our own such industries.

4 Can tobacco, cotton, peanuts, sweet potatoes, and similar crops be mechanized for quantity production and quality control? On many of these products the surface of the research that needs to be done has barely been scratched.

5 How valuable is the labor that is performed about the farm buildings in caring for livestock and crops? In dairying, for example, and in producing poultry and eggs, up to 80 per cent of the labor time is spent in the buildings. The time required to care for one cow ranges from 100 to 165 man-hours per year, with an average of 140 hours, while a flock of 125 laying hens and pullets will require approximately 200 man-hours. Compared with crop production these requirements are extremely high. What is needed in new machinery or equipment and arrangement of buildings and work procedures to reduce the labor needed?

6 How much does the producer pay for inefficiency in farm processing plants and small industries handling farm products, and what can engineering do to reduce costs? Output per worker varies as much as 25 per cent in creameries within the boundaries of one county, 800 per cent in milk marketing, and 65 per cent in poultry-processing plants.

7 What do we need to know about housing farm animals to lower costs of production, improve quality of product, and maintain the health of the animals? The superintendent of the dairy herd at the USDA Agricultural Research Center says that many of the most valuable cows were ruined by cramped stalls until the losses were stopped by expanding the housing quarters. More attention needs to be given to these conditions for production within the farm buildings and for proper design. Engineers need scientific data on the heat and moisture production of the various kinds of animals in order to provide the right environment for high production and to protect the structures themselves from damage by decay and other ravages.

8 Can the potentiometer be used to supplant the seed germination test as a means for determining seed viability and growth characteristics? Some experiments have shown rather startling results and indicate that this instrument may have untold value to the plant breeder.

9 Does anyone know or can any of us even imagine the possibilities in use of bactericidal, *(Continued on page 346)*

Excerpt of a paper presented before the Engineering Education Section, Association of Land Grant Colleges and Universities, at Washington, D. C., November, 1947.

ARTHUR W. TURNER is assistant chief, Bureau of Plant Industry, Soils, and Agricultural Engineering, U. S. Department of Agriculture, in charge of agricultural engineering research.

The Effect of Spillway Storage on the Design of Upstream Reservoirs

By M. M. Culp

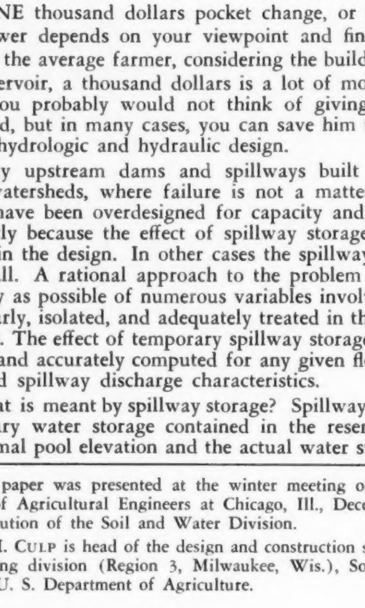
IS ONE thousand dollars pocket change, or isn't it? The answer depends on your viewpoint and financial status. To the average farmer, considering the building of a dam and reservoir, a thousand dollars is a lot of money, even today. You probably would not think of giving a farmer a thousand, but in many cases, you can save him that much by proper hydrologic and hydraulic design.

Many upstream dams and spillways built in relatively small watersheds, where failure is not a matter of life and death, have been overdesigned for capacity and, hence, were too costly because the effect of spillway storage was not included in the design. In other cases the spillways were made too small. A rational approach to the problem requires that as many as possible of numerous variables involved be identified clearly, isolated, and adequately treated in the engineering analysis. The effect of temporary spillway storage can be completely and accurately computed for any given flood, reservoir site, and spillway discharge characteristics.

What is meant by spillway storage? Spillway storage is the temporary water storage contained in the reservoir between the normal pool elevation and the actual water surface during flood flow. Normal pool elevation is the elevation of the water surface in the reservoir just after discharge has stopped in all of the spillways and before evaporation, seepage, and other losses have lowered the water surface.

This paper was presented at the winter meeting of the American Society of Agricultural Engineers at Chicago, Ill., December, 1947, as a contribution of the Soil and Water Division.

M. M. CULP is head of the design and construction section, regional engineering division (Region 3, Milwaukee, Wis.), Soil Conservation Service, U. S. Department of Agriculture.



NOMENCLATURE

A = area of watershed in acres
a = area of reservoir at elev. of crest of principle spillway (normal pool elev.) in acres
d = stage in feet above crest of principal spillway
D = average depth of run off in inches
Qi = peak rate of inflow in c.f.s. (cubic feet per second)
Qo = rate of outflow in c.f.s. when the principal spillway first flows full as a pipe (under pressure)
R = total flood volume in acre feet
S = average slope of banks of reservoir, through range of stage d, in percent
T = total duration of inflow in minutes
Va = available storage in acre feet
Vr = required storage in acre feet
β = ratio of Qo to Qi or Qo ÷ Qi

EQUATIONS

$$Va = ad + \frac{0.85\, d^2 \sqrt{a}}{S} \quad \text{------------} (7)$$

$$\beta = \frac{Qo}{Qi} = 1.25 \pm \sqrt{\frac{18\,Va}{AD} + 0.06} \quad \text{------------} (10)$$

$$d = -\frac{S\sqrt{a}}{1.70} \pm \sqrt{\left[\frac{DAS}{30.6\sqrt{a}}(1-\beta)(3-2\beta)\right] + \frac{a\,S^2}{2.89}} \quad \text{--} (11)$$

Fig. 1 This graph indicates the proportions of the assumed inflow and outflow curves for the reservoir

During a storm, as the flood water flows into the reservoir, the stage or elevation of the water surface rises to a maximum height and then recedes. Meanwhile, there has been a temporary detention, or holding back of a volume of water, the magnitude of which depends upon the size of the reservoir or lake, the capacity of the spillway, and the rate at which the water flowed into the reservoir.

The above relationship can be described mathematically by the "storage" equation which follows:

$$I = O + S \qquad [1]$$

where

I = the total inflow into the reservoir
O = the total outflow from the reservoir
S = the change in storage in the reservoir.

This equation must be satisfied at any and all times during the period from the beginning of inflow until outflow has stopped; hence, it must also be satisfied for any time interval between the above limits.

Then, letting

t = duration of small time interval in seconds
i_1 = inflow rate at beginning of time interval t in cfs
i_2 = inflow rate at end of time interval t in cfs
o_1 = outflow rate at beginning of time interval t in cfs
o_2 = outflow rate at end of time interval t in cfs
s = increase or decrease in storage in time interval t in cu ft

$$t\left(\frac{i_1 + i_2}{2}\right) = t\left(\frac{o_1 + o_2}{2}\right) + s. \qquad [2]$$

To be mathematically correct, the above equation would have to be stated in terms of differentials, but for all practical purposes, it is sufficiently accurate if reasonable values are chosen for the time interval t.

Numerous algebraic, graphical, and semigraphical methods for solving the above equations are contained in the technical literature on the subject. They all depend upon three relationships which are usually presented in graphical form:

The inflow hydrograph gives the rate of inflow as a function of time from beginning to end of runoff into the reservoir.

The spillway storage curve shows the volume of storage in the reservoir for various stages of the water surface above some fixed elevation, above which the effect of spillway storage is to be computed. This curve is obtained from calculations based on the topography of the reservoir.

The spillway discharge curve shows the relationship between the rate of outflow through the spillway and the stage or elevation of the water surface in the reservoir.

The rate of outflow and the storage volume can be determined at any time from the above relationships and the storage equation.

There are several advantages to be obtained by the consideration of spillway storage in the design process.

Often the total cost of the dam under consideration can be materially reduced. This saving usually results from a reduction in the size and cost of the required spillway.

The cost of other elements of the water-disposal system below the dam under consideration is often favorably affected by a reduction in the peak rate of flow for which they should be designed. Flood channels, drainage ditches, and

spillways below and in relatively close proximity to the detention reservoir probably can be reduced in size and cost.

Proper location and design of detention dams may eliminate the need for additional stabilizing dams below. Reduced velocities which result from a reduction in a peak discharge rate will often change existing channels below the dam from a state of active erosion to one of stability, or permit the design of new channels on steeper grades than would otherwise be permissible.

The use of spillway storage must be accompanied by certain precautions.

An emergency spillway should be used in all cases where the size of the principal spillway is reduced as the result of a consideration of temporary storage or where the principal spillway is of a size and type that might become clogged with debris. In fact, it is highly desirable to design an emergency spillway for all small upstream dams that cannot be economically designed to carry maximum floods. The emergency spillways commonly used in such cases are of the open channel vegetated type and usually are not constructed to a stable grade in the channel below the dam, but rather are extended only far enough to protect the main dam embankment. In practically all cases such spillways are easily constructed at very low cost since the earth excavated in their construction can be used in the upper part of the earth dam embankment.

Adequate provision must be made for the storage of silt in the reservoir. Silt will continue to reach the reservoir even after all practical land use measures and erosion control practices have been applied to the watershed. Obviously, if space which has been allocated to the temporary storage of water is consumed by silt, then the assumptions on which design was based are no longer valid. Since spillway storage is considered only in that part of the reservoir space above normal pool elevation, this problem does not become acute, in so far as spillway capacity is concerned, until the reservoir has been silted full to crest elevation of the principal spillway and above.

The lower the ratio of peak outflow rate to peak inflow rate, or, in other words, the greater the effect of temporary spillway storage, the longer it will take to lower the water surface to its normal elevation. As the duration of outflow is prolonged, the probabilities of a subsequent storm before the reservoir has been emptied to receive its regular runoff, become greater. The designer must take care lest he defeat his purpose.

In planning erosion control dams it often becomes desirable to estimate the effect of spillway storage for a particular dam site early in the design process. The following procedure which has been developed to meet this need is limited in its use by the assumptions made in its derivation. The principal assumptions are shown in Fig. 1, which indicates the proportions of the assumed inflow (OAC) and outflow (OEB) curves for the reservoir. It should be apparent that spillways of the drop-inlet type, which will flow at nearly constant capacity with a relatively low head over the spillway crest, have discharge characteristics that can be approximately represented by the assumed outflow hydrograph.

The total flood volume represented by the area, OACO, under the inflow hydrograph in Fig. 1 is equal to 0.5 $Q_i T$. Since it is desirable to express discharge in cubic feet per second (cfs), time in minutes, and volume of runoff in acre-feet, the formula for total flood volume in those units is

$$R = \frac{\frac{1}{2} Q_i T \times 60}{43560} = \frac{Q_i T}{1452} \qquad [3]$$

where R = total flood volume in acre feet

Q_i = peak rate of inflow in cfs

T = total duration of inflow in minutes.

The total flood volume may also be expressed as a function of the size of the watershed and the average depth of runoff. Hence

$$R = \frac{DA}{12} \qquad [4]$$

where D = average depth of runoff in inches

A = area of the watershed in acres.

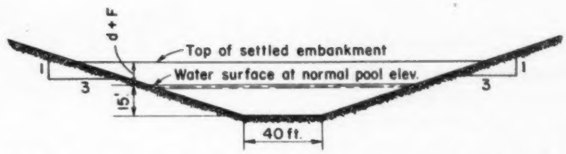


Fig. 2 A cross section of the gully along the center line of the earth embankment

Elimination of R from equations [3] and [4] gives

$$T = \frac{121\,A\,D}{Q_i} \qquad [5]$$

For a proper design the available spillway storage will be equal to the required spillway storage for the assumed design storm as represented by the inflow hydrograph.

The available spillway storage can be expressed with sufficient accuracy as a function of the surface area of the reservoir at crest elevation of the principal spillway, the average side slope of the reservoir just above crest elevation, and the depth of water or stage above the crest of the principal spillway. This functional relationship is based on the assumption that the actual reservoir may be replaced by the frustrum of a cone. The volume of the frustrum of a cone is

$$V = ad + 0.849\frac{d^2\sqrt{a}}{S} + 0.2404\frac{d^3}{S^2} \qquad [6]$$

After dropping the last term of equation [6], which is relatively insignificant, the available spillway storage becomes

$$V_a = ad + \frac{0.85\,d^2\sqrt{a}}{S} \qquad [7]$$

where V_a = available storage in acre-feet

a = area of reservoir in acres at elevation of crest of principal spillway

d = stage in feet above crest of principal spillway

S = average slope of banks of reservoir, through range of stage d, in per cent.

The required spillway storage is represented by the unshaded portion of the hydrograph, Fig. 1, area OABEO. This volume is

$$V_r = \frac{1}{2}(Q_i - Q_o)\left[\frac{1}{3}\,T + \left(\frac{Q_i - Q_o}{Q_i}\right)\frac{2}{3}\,T\right]$$

Upon simplification and the substitution of numerical values to make the units consistent, this equation becomes

$$V_r = \frac{T}{4356\,Q_i}(Q_i - Q_o)\quad(3Q_i - 2Q_o) \qquad [8]$$

where V_r = required storage in acre-feet

Q_i = peak rate of inflow, in cfs

Q_o = rate of outflow, in cfs, when the spillway first flows full as a pipe (under pressure)

T = total duration of inflow in minutes.

But V_r must equal V_a, hence

$$\frac{T}{4356\,Q_i}(Q_i - Q_o)\,(3Q_i - 2Q_o) = ad + 0.85\frac{d^2\sqrt{a}}{S} \qquad [9]$$

Now substitute the value of T from equation [5] in equation [9], and let $Q_o/Q_i = \beta$, and simplify. The resulting equation is

$$\frac{Q_o}{Q_i} = \beta = 1.25 \pm \sqrt{\frac{18}{AD}\left(ad + 0.85\frac{d^2\sqrt{a}}{S}\right) + 0.06} \qquad [10]$$

By solving equation [9] for d, we obtain

$$d = -\frac{S\sqrt{a}}{1.70} \pm \sqrt{\frac{DAS}{30.6\sqrt{a}}(1-\beta)\,(3-2\beta) + \frac{a\,S^2}{2.89}} \qquad [11]$$

Equation [1] is useful in estimating the required capacity

TABLE 1

Design Number	1	2	3	4	5
Diameter of pipe, in inches	36.	21.	18.	15.	12.
Required height of fill, in feet	18.9	18.9	19.1	19.4	19.6
Q_0 = peak outflow rate in cfs	119.	30.	23.	15.	8.
$\beta = Q_0/Q_1$	1.00	0.25	0.19	0.13	0.07
Cost of embankment and spillway	$2435.	$2142.	$2035.	$2049.	$2053.
Excess cost above minimum	$400.	$107.	$0.	$14.	$18.
Approximate duration of outflow, in hours	1	4	5	7	13
Allowable grade in feet per foot in channel below spillway having bottom width of 4 ft, side slopes 1 to 1, n = 0.04, and an allowable velocity of 4.5 fps	0.00072	0.0177	0.0216	0.0347	0.0623

of the principal spillway where the physical features of the reservoir and the maximum allowable stage above the crest of the principal spillway are known. It should be noted that the term, $ad + 0.85\ (d^2\sqrt{a}/S)$, in the right-hand side of [10] is the available storage capacity. If a satisfactory contour map of the reservoir site is available, this value can be computed directly and substituted in equation [10]. Such a procedure will increase the accuracy of the result over that which might be obtained on the basis of a measured value of a and an estimate of S from hand level measurements.

However, if it is desirable to limit or control the flow in the channel below the proposed spillway so as to permit steeper grades without excessive velocities, or for some other reason, equation [11] may be used to compute the required stage at any given site for a selected value of β. Here, as before, most accurate results can be obtained if the topography of the reservoir is available in the form of a good contour map. Then equation [7] can be solved for s for various values of d and the results used in computing d from equation [11].

In all cases, a, the surface area of the reservoir at crest elevation of the principal spillway, must be accurately determined.

This approximate method of estimating the effect of temporary spillway storage, where drop inlet spillways are used, is not a substitute for the more precise methods. The above equations have been found to be valuable timesavers in the preparation of preliminary estimates and in the preliminary stages of the final design process.

For example, one of the dams in the Kirkholm subwatershed of the Little Sioux Basin in western Iowa has the following characteristics: $D = 3.17$ in, $A = 113$ acres, $S = 6.22$ per cent, $a = 1.93$ acres, and $\beta = 0.146$. By accurate graphical solution of equation [2], the correct value of d was found to be 6.82 ft, whereas from equation [11], the value of d is 7.04 ft, in error by 3.2 per cent. Equation [11] normally does not give quite such accurate results; however, its accuracy is usually adequate to justify its use as indicated above.

To clinch the basic arguments in favor of design procedures which incorporate the effect of temporary spillway storage, consider a typical example. Assume the following conditions:

A = 40 acres, drainage area
a = 2.50 acres, normal reservoir area
D = 2.50 in, depth of runoff
F = 2.00 ft, freeboard
Q_1 = 120 cfs, peak rate of inflow (runoff)
S = 10 per cent, average side slopes of reservoir
Side slopes of earth fill = 2 to 1 and 3 to 1
Top width of fill = 10 ft
Total controlled head = 15 ft

A drop-inlet spillway with a reinforced concrete inlet and metal pipe barrel with two antiseep collars.

A cross section of the gully along the center line of the earth embankment as shown in Fig. 2.

Five designs have been made on the basis of the above physical data and the assumptions outlined below.

Design No. 1: In this design the effect of temporary spillway storage was ignored and the spillway designed to convey the peak runoff of 120 cfs. The height of the embankment was determined from weir flow requirements on the inlet plus freeboard.

Design No. 2: The height of embankment was kept the same as in design No. 1, and the effect of temporary spillway storage included to effect a reduction in the size of the spillway. A constant freeboard of 2.00 ft was used in all designs.

Design Nos. 3, 4, and 5: These designs were made for decreasing sizes of spillway, and the embankment was raised sufficiently in each case to provide the needed additional temporary spillway storage in the reservoir.

After the designs were completed, a cost estimate was made for each, based on reasonable construction costs for each principal item of work involved.

The results of this study are given in Table 1. For this case, proper design would save $400 and result in a more stable grade below the spillway. Numerous cases have occurred in the author's experience where such savings have been $2,000 or more. Obviously generalizations cannot be made from the one example given. Each case constitutes a separate problem. The topography of the dam site and of the reservoir, the relative cost of the various items of work, the cross section of the earth embankment, the shape and volume of the inflow hydrograph, and the size and type of spillway and the materials used in its construction, affect the possible economies to be obtained for any particular structure.

In almost every case where the effect of spillway storage has been included in the design, the saving in the cost of the dam has been several times as great as the added engineering cost involved. In the example cited above, the increased engineering costs should not exceed $75 and probably would be less. A $400 return for $75 spent is good engineering and good business.

Ag Engineering Research Problems

(*Continued from page 343*)

erythemal, and infrared energy in agriculture? In this field of electric radiation, preliminary explorations have already indicated a tremendous field for research of especial immediate interest in the possibilities of supersonic energy and its effects on plant, bacterial, insect, and animal life.

10 What types of refrigeration equipment for farm use will be required in the future? In so far as farm applications are concerned, refrigeration is just in its infancy. The possibilities of freezing fresh milk on the farm are, for example, just becoming known. In the not-too-distant future, poultry also may be fresh-dressed, frozen, and sold directly from farms. With further research in farm refrigeration, the marketing of many perishable farm products might easily be revolutionized. Equipment to handle such demands has not yet been designed.

The foregoing are only a few of the problems of the moment about which agricultural engineers are thinking. In agricultural research it is sometimes difficult for many to distinguish the engineering phases because so often the work is set up by commodities–cotton, corn, hogs, cattle, or other crops or animals. In all these fields, however, there are engineering phases. This work might well be described as functional research because so often it deals with the functions of production, storage and housing, processing, and marketing. In agricultural engineering the investigations are concerned not only with crops and their production, but also with the functional requirements of livestock shelters, the development of more livable homes, and the efficient use of labor, mechanical power, and electricity on the farm and in the rural farm industries. It is estimated that 85 per cent of the nation's vast agricultural research program has engineering phases or implications.

The Development of a New Sugar Beet Harvester

By John B. Powers

THE beet crop has traditionally required a large amount of field labor for thinning and harvesting operations. Since this type of labor is hard to obtain in periods of high employment, the supply of beets to sugar factories has been unstable. In recognition of this problem, the beet-processing companies initiated a movement in 1938 to organize and intensify research in the field of sugar beet production. One phase of their work was the establishment at Davis, Calif., of a joint project between the University of California and the U.S. Department of Agriculture. The purpose of this project was to investigate the possible fields of mechanization in beet growing, and to encourage and assist farm equipment manufacturers in the design of sugar beet machinery. This paper describes one part of the work — an attempt to develop a mechanical beet harvester.

A large number of beet harvester patents have been granted in this and other countries during the past 50 years. The machines described in them may be roughly classified into two types: those in which beets were first topped and then lifted, and those in which this sequence of operations was reversed. The former were capable of fairly precise topping but were unable to separate beets from soil except under unusually favorable conditions. The latter had less trouble with soil separation but were capable of only crude topping. These fundamental difficulties, plus the individual faults of each machine, prevented their early commercial acceptance. A labor shortage during World War II forced the industry to lower its standards, and the move toward mechanization was begun. Improvement in harvesters since that time has been great. However, there is yet no general agreement among growers or the farm equipment industry as to what type of machine is most desirable.

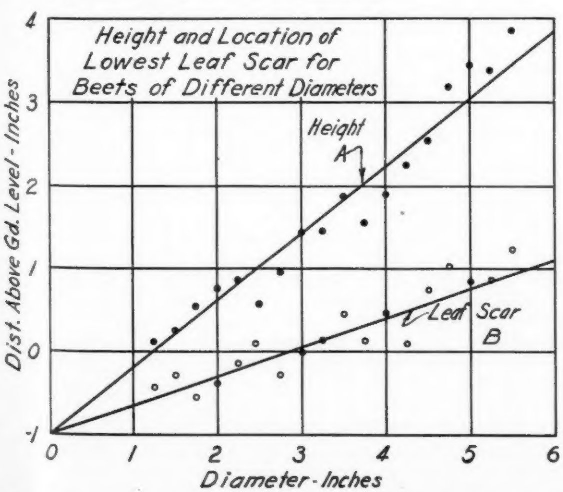
Part of this indecision is due to the wide variety of conditions under which beets are harvested. In California, with its long growing season and late fall rains, beets are usually harvested in dry, hard soil. Weeds are likely to be rank, particularly during the latter part of the harvest. Tops frequently are small. Roots are usually large, many of them projecting 8 in or more above ground level. Little attempt is made to realize the full feeding value of tops. Contracts are large, and most growers are equipped with heavy, track-type tractors. Beets are usually milled as received since the long harvest season obviates piling. Under these conditions, it is not surprising that California growers favor a fast, rugged machine that operates well in dry ground. Machine cost, precision of operation, top salvage, and power requirements are secondary considerations.

In the remainder of the country, weather conditions during the harvest are more variable and may change suddenly from very dry to very wet. Soils range from light, sandy types to heavy adobe clays. Tops are usually large, and in many areas their utilization as stock feed is a major factor in the beet economy. Roots seldom project more than a few inches above ground level except in a few restricted areas. Fields are usually free of weeds, and stands are carefully thinned. The average contract is small, and track-type tractors are seldom used. The beets must be delivered in fit condition for storage, since the harvest season is restricted to about one month. Under these conditions, the principal demand is for an inexpensive, light-draft machine that will operate under any moisture condition. Topping must be precise, and tops must be left in suitable condition for subsequent harvesting. High daily output is of secondary importance.

Before the development of a harvester could be attempted, a compromise between these two conflicting sets of requirements was evidently necessary. A study was made to determine the features of a machine which might be generally acceptable to the industry in all of the beet-growing areas. Beet growers and processors were consulted, and a study was made of losses incurred in manual harvest in the different regions. From these opinions and data, a list of requirements was compiled. These requirements described a light, fast harvester whose work would be roughly equivalent to that of hand labor under all soil and moisture conditions that prevail at harvest time. Ten years of work have produced only a partial solution of this very substantial problem. The description of this work and the bases for the decisions which have been made can conveniently be divided into four more or less independent parts: topping, plowing, root elevation, and root disposal.

This paper was presented at the annual meeting of the American Society of Agricultural Engineers at Portland, Ore., June, 1948, as a contribution of the Power and Machinery Division.

JOHN B. POWERS is associate agricultural engineer in the agricultural experiment station, University of California.



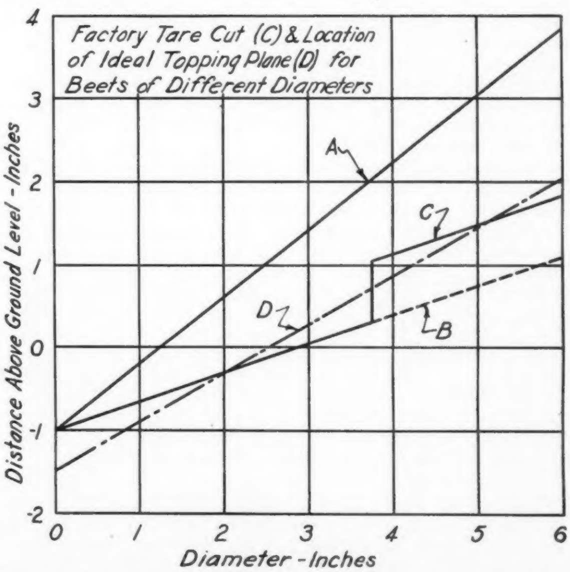


Fig. 1 (*Left*) This graph shows the approximate linear relationships between beet height, greatest diameter, and crown thickness (distance from top of a beet to its lowest leaf scar) • Fig. 2 (*Right*) Curves C and D show a method of determining the ideal topping plane

Underlying all decisions has been the theme that beet losses must be kept small. The cost of harvest by manual methods is about 13 per cent of the value of the crop. Overall losses by harvest crews average from 4 to 4½ per cent. The excess of machine losses over hand losses must be kept small in comparison with 13 per cent, or little benefit will accrue to the farmer from machine operation.

TOPPING

In receiving beets at the dump, the processing companies extract a random sample from each load. After the sample is weighed, dirt is removed from the roots, and useless portions of the crown material are removed. The sample is then reweighed, and the shrinkage or tare applied to the entire load. At the time this project was begun, the common practice was to divide the beets into two size groups: those of less than 3.75 in greatest diameter, and those of greater diameter. The smaller beets were trimmed to the level of the lowest leaf scar, and the larger ones, ¾ in higher.

Evidently, if a machine is to top a beet at a level which is measured from the lowest leaf scar, it is necessary that some dimension of a beet be indicative of the location of the lowest leaf scar. This dimension can then be used to actuate a gaging device which will place a knife in the proper position for topping. In an effort to discover such a relation, data were taken at harvest time in Colorado, Utah, Idaho, and California. Approximately linear relationships were found between beet height, greatest diameter, and crown thickness (distance from the top of a beet to its lowest leaf scar). These relationships are shown in Fig. 1.

Either beet height or greatest diameter can be used to locate the proper topping plane with respect to the top of the beet. Since the greatest diameter of a beet is often below ground level, a machine which tops beets in their growing position is restricted to the height-crown thickness relationship. The height-crown thickness relationship is usually lost during the plowing operation. Hence, machines that top after lifting are limited to the diameter-crown thickness relationship. Since topping before lifting showed the greater promise of precise work, this system was chosen for the experimental harvester.

Several kinematic, kinetic, and mechanical problems must be considered in the design of a topper. The fundamental kinematic relationships may be derived from the data shown in Fig. 1. Curves A and B, in Fig. 1 are reproduced in Fig. 2. Assume that a gaging device, or finder, passes over the top of each beet and elevates a knife to the proper topping level. The locus of the finder for beets of different diameter is curve A. Curve C indicates the height of a plane which coincides with the lowest leaf scar for beets less than 3.75 in in diameter and is 0.75 in above the lowest leaf scar for larger beets. It is the locus of the topping plane which would produce a minimum of tare at the beet dump without removing salable portions of the root.

Curve C is obviously only an approximation to curve D, broken into two parts to simplify the trimming of tare samples. Curve D would then appear to be the locus of the best topping plane for a mechanical harvester. Physically, this represents a system in which a finder is coupled to a knife through a linkage which lifts the knife 0.71 in for each one inch of rise of the finder. When the finder is at ground level, approximately 0.75 in of material is removed from a beet. The thickness of the removed slice increases 0.29 in for each inch of beet height. A machine constructed on this principle is capable of approaching the precision of hand topping, except for beets whose crowns are below ground level. Many of these smaller beets are poorly topped or are not topped at all. The reason becomes obvious when the kinematics of the system and the nature of the ground surface are considered.

At harvest time, a beet field has been roughened by cultivation and by erosion by wind and water. The ground surface, either at the base of the furrows or in the beet row, is not parallel with the seedbed in which the beets were planted. Since the laws of beet proportions shown in Fig. 1 will depend on the level of the original seedbed, it is evident that two independent variables will influence the amount of ma-

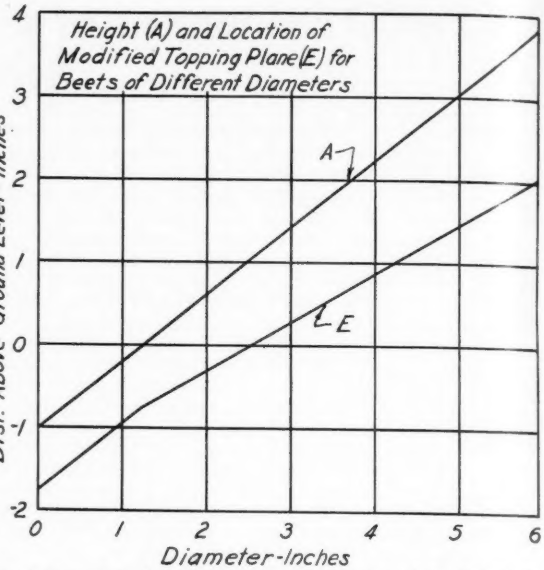


Fig. 3 Curve E in this graph shows a modification of the finder-knife relationship indicated in curve D of Fig. 2

terial removed from each beet: the height of a beet above ground level and the displacement of ground level from the original seedbed. In mechanical terms, these variables are the movement of the finder with respect to the topper frame and the movement of the topper frame with respect to the original seedbed. Since this latter movement may be as great as plus or minus 1.5 in, an error of plus or minus 0.44 in in the thickness of the removed slice is possible. Whereas an occasional error of this magnitude in the topping of a large beet is scarcely noticeable, it may result in failure to remove the leaves from a small beet.

It has, therefore, been found desirable to modify the finder-knife relationship indicated in curve D, Fig. 2, to that shown in curve E, Fig. 3. Curve E is a reproduction of curve D down to the point where the spacing between finder and knife becomes 0.75 in. From that point, the spacing remains constant as the finder falls. This arrangement greatly reduces the top tare on small beets without causing appreciable topping loss.

Evidently the finder must place the knife at the proper topping level at the instant that the knife enters a beet. Thus a further kinematic requirement for the topping mechanism is that the gaging point on the finder lead the knife edge by the radius of the beet. When design is based on greatest beet radius, this relationship may be departed from by as much as 30 per cent of the radius without introducing appreciable topping error. This is true because the beet diameter at the topping plane is less than the greatest diameter, and because beets are relatively flat topped over an appreciable area. It is further desirable that the knife edge move as nearly as possible in a vertical plane with respect to the frame of the machine. This prevents the knife from swinging forward as it leaves a high beet, thus skipping over a low beet which might immediately follow. Since the finder cannot move forward bodily as it rises without breaking high beets, it is necessary that the gaging point on the finder surface shift forward as the finder is raised. Thus the required contour of the finder surface may be determined This shape is best found by assuming a set of reasonable dimensions for the topping mechanism and then altering this choice by graphical cut-and-try methods with the aid of the data in Fig. 3.

It has been found that a wedge-shaped knife passes through a beet in a plane parallel with the lower surface of the knife. It is, therefore, desirable that the knife in a mechanical topper be mounted with its lower surface parallel with the ground. However, a knife will not penetrate hard ground or cut its

way through leaves and trash on the surface of soft ground unless its clearance angle with respect to the surface is at least 8 deg. A knife mounted at this angle will cause appreciable loss through slant topping of large beets. This conflict was reconciled in the experimental topper by devising a mounting which holds the knife parallel with the ground when elevated but tilts it to the required angle as it approaches ground level. The slant topping of small beets which results is barely discernible.

In addition to the kinematic requirements discussed above, certain kinetic relationships must be considered in topper design. One of these is a result of the limited capacity of high beets to withstand a horizontal force at the crown. This is particularly true in moist or sandy soil where beets may be readily overturned. To evaluate this effect, tests were made in wet fields containing high beets. A vertical hole was drilled through the crown of a high beet, and a rod was inserted in the hole. A measured force was exerted on the rod at the level of the beet top and was increased until the beet was overturned. Values of this force varied widely for apparently similar beets in the same field. However, few beets were overturned with a force of less than 60 lb and many with a force of 75 lb. Hence it was decided that the horizontal component of the force necessary to raise the topping mechanism should not exceed 60 lb.

Another kinetic requirement is that the topping mechanism return promptly to ground level after topping a high beet. Except in very small beets, mechanism which falls through the effect of gravity alone will not operate successfully at practical harvesting speeds. Spring pressure used to accelerate the fall must not, however, be so great that beets will be overturned in their effort to lift the finder. Since the rate of fall is governed by the ratio of spring pressure to the mass of the moving parts, a limitation is placed on the permissible weight of the topping mechanism.

It has been shown[1]* that to obtain best results from a mechanical topper:

$$W = 72.5/S^2 \text{ and } F_s/W = 0.785S^2 - 1$$

where W = maximum permissible weight of topping mechanism referred to the gaging surface (lb)

S = harvesting speed (mph)

F_s = downward component of spring thrust on gaging surface (lb)

If 2.5 mph is assumed to be a reasonable harvesting speed,

*Superscript numbers refer to appended references.

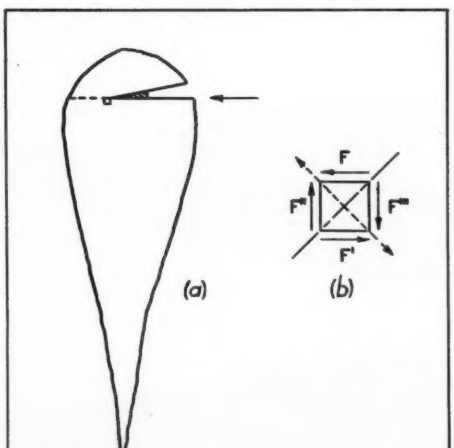


Fig. 4 Graphic illustration of breakage of a beet root caused by drawing a knife through the crown

then W = 11.6 lb and F_s = 45.2 lb. It is difficult, but not impossible, to design topping mechanisms to fulfill these requirements and to possess the necessary qualities of strength and rigidity. The problem has been solved in the experimental unit by devising a narrow finder which is automatically centered on each beet. The narrow finder has the further advantage of being able to thread its way through heavy tops and weed growth.

Since W is the effective dynamic weight of all parts of the topping mechanism when referred to the gaging surface, it will differ from the static weight as measured at that surface. An accurate computation of W is tedious. It may be estimated for purposes of preliminary design and then measured by a simple process. If the topping mechanism is supported by a vertical spring attached to the gaging surface of the finder, and the natural frequency of the combination is found,

$$W = 9.8\ (k/f^2)$$

where k = the constant of the supporting spring (lb per in)

f = the natural frequency of the combination (cycles per second).

The foregoing kinematic and kinetic analyses do not consider the actual cutting operation. It has been found that a knife drawn through beets which are supported only by soil will frequently cause breakage of the roots. This is particularly true when the beets are in a crisp and turgid condition. Usually the knife will cut approximately two-thirds of the way through a beet. Failure will then occur on a plane sloping downward and forward from the cutting edge at an angle of 45 deg. The explanation for this breakage is simple. In Fig. 4 a, a knife is shown passing through a beet in the direction of the arrow. The forward thrust of the knife, which is necessary to sever the beet fibers and to overcome the friction between knife and crown, sets up a shear stress along the plane shown by the dotted line. An elementary particle along this plane is enlarged in Fig. 4 b. The shear force F generates the counter force F', and the couple $F-F'$ generates the opposing couple $F'' - F'''$. If F and F'' are replaced by their resultant and F' and F''' are similarly replaced, it is seen that a tensile stress exists on a 45-deg plane. In common with most brittle materials, a beet is relatively strong in shear and weak in tension. Thus failure occurs along a 45-deg plane.

To prevent breakage, the cutting thrust of the blade may be reduced or a counter force may be applied to the beet crown. The cutting thrust has been found to be approximately proportional to the effective included angle of the knife edge in the direction of its travel through the beet. The effective included angle may be reduced by grinding the knife to a smaller included angle or by imparting to the knife a component of velocity parallel with its cutting edge. The first alternative requires that a knife be ground to an included angle of 5 deg to prevent root breakage. The resulting edge is too fragile for practical use. The minimum angle which has been found to produce a reasonably durable edge is 12 deg. Even at this angle, the knife must be carefully heat-treated and drawn to a hardness of 45 Rockwell C to prevent curling or chipping of the edge.

A component of velocity parallel with the cutting edge may be imparted by mounting the knife at an acute angle to the row, by oscillating a knife longitudinally or by cutting with the edge of a rotating disk. The first scheme increases greatly the distance following a high beet which the knife must travel before it can return to ground level. The design of oscillating blades and disk knives has been discussed in an earlier paper[1].

In the early years of this project, a topper was constructed which employed a sliding shoe finder and an oscillating knife. This plan was abandoned in favor of a non-oscillating knife and a finder equipped with a cleated chain, power driven to impart a rearward thrust to the beet crowns. There were several reasons for this change. The mechanism required to oscillate the knife at the required rate was troublesome. The tendency of leaves and trash to clog the finder is eliminated by the chain. Since the driven chain climbs beets rather than

slides over them, there is less tendency to overturn loose beets. Finally, the quality of topping is at least equal to that obtained with the oscillating blade.

A modification of the linkage connecting finder and knife is required if the finder is to impart a force to the beet crown throughout the cutting operation. The gaging point on the finder is at the center of a beet when the knife begins its cut. Hence the finder will be beyond the beet as the cutting operation is completed. It is at this point that the danger of breakage is greatest. This fault may be corrected by employing a slip link to elevate the knife. This linkage raises the knife to the proper topping plane as before described. Once the knife has entered the beet, it will continue to move in a horizontal plane without outside support. The slip link then permits the finder to fall without lowering the knife. By this means, the finder may be caused to hug the beet crown throughout the cutting operation.

The experimental topper developed in this project has been designed in accordance with the foregoing analysis. Some of the other features of the machine are worthy of note. The frame of the topper is carried on shoes which slide along the ground adjacent to the beet row. This ground is less disturbed by irrigation and tillage than the furrows. Hence a more uniform datum for the topper linkage is obtained than with a machine connected rigidly to a tractor. Tops are gathered and windrowed by two rotating drums equipped with flexible fingers. This device has proved simple and efficient.

PLOWING

A pair of conventional beet-lifting points used in loosening beets for manual harvest is shown in Fig. 5. The blades operate along either side of a beet row at a depth of approximately 7 in. This plow is unsuited in many ways to mechanical harvesting. In hard ground, the soil is broken into large chunks. The thickness of these clods is often equal to the depth of the plow. It is obviously difficult to gather beets from such a soil mass without picking up some of the clods. No mechanical system has yet been developed which will separate beets from clods once they have been mixed.

The conventional plow has little off-row tolerance. It is evident from Fig. 5 that a beet which is appreciably off-center will be struck by the leading edge of the plow blade before it is loosened. A broken tap root is the usual result. The remaining portion of the beet is likely to roll out of position before it can be grasped by a pickup device. Another unfavorable feature of the plow is its failure to loosen small beets in wet soils. It does not compact the soil around the root firmly enough to provide a coupling through which the beet can be lifted.

In this project, an effort was made to devise a plow which would be more suitable for mechanical harvesting than the traditional type. The form which was finally evolved is shown in Fig. 6. It consists of two pieces of strip steel, twisted about their outer edges as axes to form a right-hand and a left-hand helicoid. The surfaces at the rear of the plow are horizontal, and those at the front are at an angle of 10 deg from vertical. The leading edges slant back at an angle of 30 deg from vertical and are ground on the outside to an included angle of 22.5 deg. The outer edges of the plow points are parallel and slope downward and forward at an angle of 2.5 deg. Various blade sizes and helical pitches were tested under different soil conditions. The best size for all-around work was found to be 0.5 x 3 x 18 in, and the optimum pitch, 4½ deg per in. The spacing between blades is 8 in at the front of the plow and 2 in at the rear.

The tips operate 5 to 6 in below ground level. Soil entering the space between the nearly vertical faces at the front of the plow is squeezed firmly against the beet roots as the plow progresses. Beets and soil are then lifted by the twisted blades. A strong lifting effort is possible because of the initial compaction of the soil below the bulge of the beets. The soil included between the points is thoroughly broken up by crushing before it is lifted.

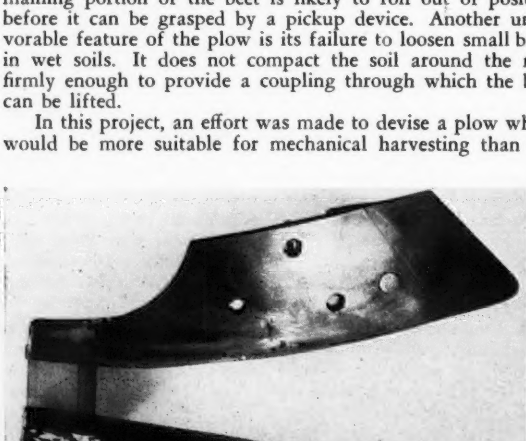
Since a beet is approached by a nearly vertical plane, it is not cut off or broken if not centered between the points. By the time the plow has progressed to the point where its leading edge strikes the root, the beet has been lifted and may be shifted without breakage. Thus the plow is less sensitive to off-row operation than the older types.

The layer of soil which lies above the plow points is, of course, not crushed. In hard ground, it comes over the plow in slabs about 3 in thick. In the experimental harvester, these slabs seriously interfered with beet recovery. To shatter these slabs, a pair of spiked wheels driven at ground speed was mounted above the plow. A dihedral angle of 45 deg between the planes of these wheels permits large beets to pass between them.

ROOT ELEVATION

The difficulty of separating soil from beets may be appreciated by considering the rate at which material must be handled. A beet plow 8 in wide, which operates 6 in below ground level at a speed of 2½ mph lifts 2.72 cu yd of soil per minute. This is equivalent to 480 tons of soil per acre. A good crop may yield 20 tons of beets per acre. A reasonably clean load of beets does not contain more than 5 per cent of loose dirt. Thus, of the 480 tons of soil lifted in harvesting an acre, only one ton may be delivered with the beets. It is, therefore, necessary that the harvester be about 99.8 per cent efficient in separating soil from beets.

To construct a machine of this precision in a reasonable space and with limited power requirements that will handle soil at this rate is a formidable problem. Only one commer-



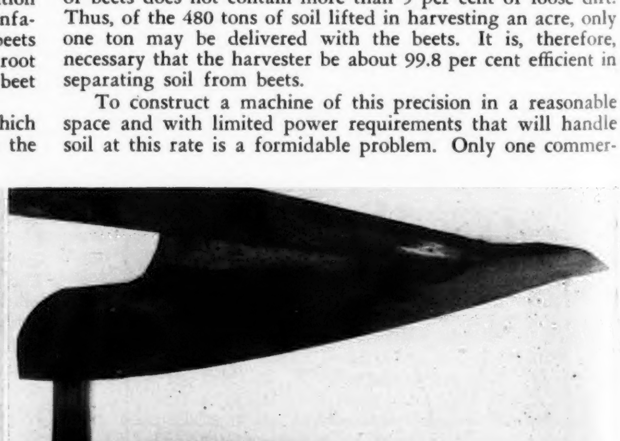


Fig. 5 (*Left*) A pair of conventional beet-lifting points used in lifting beets for manual harvest • Fig. 6. (*Right*) A new beet-lifting plow developed by agricultural engineers of the California Agricultural Experiment Station

cial harvester fulfills these requirements by mechanical means under all soil and moisture conditions. It is designed to elevate beets by grasping their leaves between gathering chains. It fails, however, to operate successfully when tops are small or when roots are large. Another harvester, which eliminates most of the soil under dry conditions, impales beets on the rim of a spiked wheel. Since the ground is penetrated only a few inches by the spikes, very little dry soil clings to them. Wet soil, however, adheres to the wheel in such quantity as to make the system impractical. Other commercial harvesters elevate both beets and soil and attempt a separation by screening. This has proved practical only in friable soils or where hand labor is used to accomplish the final separation.

It is significant that the versatility of these machines in operation under different soil conditions is an inverse function of the amount of soil contacted by the root-grasping mechanism. Hence, in this project, an attempt was made to devise a machine which would grasp the roots at points removed from the soil mass. The only part of a small beet which is exposed by the plow is the taproot, where it projects down between the plow blades. In larger beets, both the taproot and the portion of the beet which projects above ground level are free of surrounding soil. In the experimental harvester, a pair of gathering chains is mounted slightly below the plow surface, extending up and back from the rear of the plow at an angle of 22.5 deg. As beets leave the plow, they are trapped between the chains and carried to an elevator at the rear of the machine. Since soil from the plow passes over the jaw between the chains, it is not conveyed by them to the elevator. The chains operate under a tension of 75 lb and are backed up at intervals of 8 in with swinging idler pulleys. These pulleys are equipped with short springs in such manner that the force against the taproot varies from 8 lb for a root 0.25 in in diameter to 30 lb for a 1.5-in root.

A second pair of chains is similarly mounted slightly above the ground surface to grasp the crowns of the larger beets. Flexible rubber fingers attached to these chains adapt themselves to beets of different diameters.

A considerable quantity of dirt is delivered with the beets to the elevator. In wet fields, soil adheres to the beet roots. Most of this can be removed by tumbling the beets in the elevator. Under dry conditions, soil is carried up between beets. It has been minimized by operating the pickup chains at a rate 30 per cent greater than ground speed. This increases the separation between beets as they enter the chains and permits most of the soil to fall free. The remaining fraction is, however, significant.

The thickness of the soil fragments delivered by the plow is usually less than the spacing between the upper and lower pickup chains. Occasionally, however, a clod is large enough to be trapped between the two pairs of chains. It is difficult to eliminate these large clods in the screening mechanism, and most of them appear in the load. Fortunately their number is not ordinarily sufficient to prevent successful operation.

One of the weaker features of this system of harvesting is the loss of small beets through spreading of the pickup chains by adjacent large beets. This makes root recovery somewhat dependent on quality of thinning. Also, since the operating principle is based on conical root shape, the machine is not well adapted to the harvest of misshapen roots. Partially offsetting these disadvantages is the fact that all unharvested beets are left lying on the ground surface where they may be picked up by a man following the machine.

ROOT DISPOSAL

Three systems of root disposal are used in commercial beet harvesting. In one, several rows of harvested beets are placed in a windrow to be picked up later by a separate machine. This scheme minimizes the amount of conveyor mechanism carried by the harvester and permits operation of the harvesting unit when trucks are not available. The use of a separate loading machine and its associated tractor, however, increases the total amount of equipment required for the job. The preparation of ground to receive the windrows and the double harvesting operation require more man-hours than single-operation systems.

Another plan is to convey beets from the harvester directly to a truck which follows the machine. This system permits high daily output when the number of trucks available is sufficient to keep the harvester in continuous operation. An operator is, however, required for each truck, since his services are needed in loading. Tops are usually left in poor condition for feeding, since many of them are run over by trucks. Perhaps the worst feature of this system is that a loaded truck cannot be successfully operated in a wet field.

A third scheme is to transfer beets from the harvester to a hopper which is towed behind it. The beets are later transferred to a truck at the edge of the field. This system is highly flexible and permits operation under all field conditions. It reduces the dependency of the harvester on a supply of empty trucks and usually requires but one truck driver for the entire operation. It permits the opening of lands through the field without damage to unharvested beets. Its principal disadvantages are the time lost in transferring beets to the truck and the loss of maneuverability which is characteristic of articulated machines.

In this project a combination hopper and loader has been developed. It is a long, shallow bin which is mounted on the tractor that carries the harvester. It extends from the rear of the tractor to a point several feet in advance of the front wheels. Its floor is eight feet above ground level. Beets are introduced at the rear and are moved slowly forward by a drag conveyor as the harvester progresses. They are delivered from the forward end of the hopper to a truck at the edge of the field.

The hopper does not affect the maneuverability of the tractor. Its load of 1.25 tons of beets can be transferred to a truck in 15 seconds. No screening is accomplished during this transfer, however, in contrast with the trailed hopper. As the hopper is loaded, traction available to operate the harvester is increased. The reverse is true with the trailed hopper. Many implement engineers look askance at the practice of carrying static loads on a wheel tractor, but no difficulties have been experienced in field work.

RESULTS OF FIELD TRIALS

The topping unit used in the experimental harvester has been tested in approximately 50 acres of field trials under a variety of conditions. It has never failed to operate successfully. In muddy fields, however, where tough weeds are present, its performance is often marginal. It is fieldworthy in its present form and capable of operation at commercial level. Beets up to 9 in in height can be successfully topped, and the accuracy of gaging is independent of top growth.

In quantitative tests, topping losses have seldom exceeded 1.5 per cent, and factory tare has usually been less than 3.5 per cent. This approaches the performance of average hand labor. Tops are left in single-row windrows in suitable condition for subsequent harvesting or pasturing. In general, the topper meets the standards which were set up for it at the start of this project.

The helical plow has proved successful in this system of harvesting. It is superior to conventional lifters in clod-size reduction and in increased off-row tolerance. In shallow operation, however, where its usefulness is most apparent, it is critical as to depth. Thus, to derive a maximum of benefit from its use, continuous hydraulic depth control is required.

The beet pickup device has been less successful. During its five years of development, root recovery has been successively 65 per cent, 80 per cent, 85 per cent, 85-90 per cent, and 90-97 per cent. The last figure is misleading in that it represents work in only one locality, Clarksburg, Calif. The peat loam soil in that area is neither very hard, when dry, nor very sticky, when wet. It is, however, significant that in previous years the machine did poorer work under these conditions than in sedimentary soils. Full appraisal of its performance must await further field trials. It is safe to state that the harvester will, in its present state of development, require a scavenger to recover unharvested beets.

Dirt pickup in dry soil has varied between 2 per cent and 9 per cent in trials during the past three years. Some commercial machines show a maximum *(Continued on page 354)*

Weed Control in Grain Fields with the Flexible Harrow

By Hans Sack

IN MIDDLE EUROPE the farmer spends much time controlling weeds in grain fields. Up to about 20 years ago he used for this purpose the "hackmaschine", a sort of walking cultivator which required such slow and careful work as to offer only a limited advantage over hand hoeing.

Farmers have tried to avoid the costly operation of the "hackmaschine" in grain fields by harrowing the field several times. It is easy to kill certain weeds with the harrow, when this operation is done at the right time and in the best way. Most grain is planted below the depths at which weed seeds sprout; and the grain sprouts are more deeply rooted, hardy, and resistant to stirring of the top soil than are sprouts from weed seeds. The harrow is not useful for destroying weed plants which sprout from suckers, runners, or shoots.

For efficient and effective weed control in grain fields, the harrow should not penetrate deeper in the ground than one inch, and have a maximum clearance of $3/4$ in between tine paths.

At first farmers tried to use light-weight harrows with rigid frames of wood or steel. These harrows had a total working width of 12 to 13 ft, and were composed of four sections weighing 25 to 35 lb, with 40 to 50 teeth per section. But those rigid-frame harrows had a great disadvantage. Because no field is absolutely flat, the tines did not work equally deep.

This disadvantage is overcome with the flexible harrow. This harrow has no rigid frame, but it is knitted together from different single members of round spring steel. Each tine contacts the soil surface with its own weight only, independently of the shape of the surface. Experience showed the optimal diameter for the spring steel and the most suitable forms for the points to meet the requirements of different types and conditions of soil. We formed a heavy type, with diamond-shaped tine points using $3/8$-in diameter spring steel weighing about $1\frac{1}{2}$ lb per tine; a medium type of 5/16-in diameter formed into tines with an elliptical pointed section and weighing 1.1 lb, and a light one of $1/4$-in diameter with points simply left round, weighing $3/4$ lb per tine.

Later we observed that in the same field the condition of the soil changes in different years, depending on the previous weather. Snow packs the soil down. Frost without snow loosens soil in fields with winter wheat, when the soil has a sufficient content of humus. This gave us the idea of making a flexible harrow with three parts of different weight which are simply hooked together. This universal flexible harrow, as we called it, had 4 rows of heavy, 4 rows of medium, and 5 rows of light tines. It operates effectively over a wide range of soil conditions.

This flexible harrow is a low-cost implement compared with a walking cultivator. It can be pulled either with horses or with tractors. One man can cover a large acreage in a short time, so that it is possible to use the best weather, plant, and soil condition for running the harrow. Its use at the right time after a spring rain is the best way to produce a dust mulch on top of the soil to conserve the moisture.

The most difficult point in the technique of harrowing grain fields is to use the harrow at the right moment and to avoid periods when harrowing could do damage to the grain plants. The germinating grain field can safely be harrowed from the moment the field has been drilled, up to the time one-third of the sprouts have appeared above the ground and are forming their first leaves. In the period between starting the first leaf and finishing the second leaf, damage could be done by covering the small plants with earth at a time when the germinating reserve in the seed kernel is exhausted and life depends on the assimilating capacity of the two tiny leaves. After the second leaf is fully developed, the grain plant is much more resistant and harrowing can be done thoroughly until the grain is 15 in or more high. The ground should be dry enough so that the tines crumble the earth and do not "puddle" plastic soil.

We have used flexible harrows 30 ft wide with a special beam, articulated in the center and running on three wheels. With it we were able to harrow 140 acres per day with one man on the tractor and, under extremely weedy conditions, a helper standing on the running board of the hitch beam to watch the harrow and lift some links with a steel hook when something became clogged between the tines.

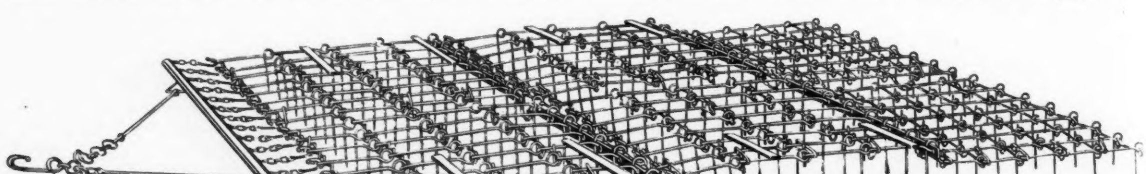
Besides the work in grain fields the flexible harrow has proved useful in some other applications.

For potato fields, the harrow adapts itself to the form of the hills and ridges. Potato fields are usually harrowed twice with the back side of the harrow—first a short time before the plants appear at the surface. By this process those weed plants standing in the plant row are thoroughly swept off. The second harrowing is done when the potatoes are 2 in above the ground with the long spikes of the harrow down. Beets are harrowed before they have become visible on the surface, with the medium or light harrow. This is especially helpful when a field sown with segmented seed has become crusty. Beans and other legumes can be harrowed before they appear and again two weeks later. On grass land the heavy flexible harrow is an excellent tool for pulling out moss plants and dried grass and to spread mole hills. On pastures the flexible harrow is the best implement for spreading heaps of manure.

Apart from those more specialized operations for diversified farming, I believe that the application of the flexible harrow will be specially useful where the grain is harvested with the combine. European farmers have observed that the population of weed plants in certain fields is increased when the harvest is done with the combine, which deposits the chaff on the field, instead of with the binder and stationary threshing machine, which blows the chaff on a pile for feeding. The high content of weed seed in the chaff is the reason for combines in Germany usually being equipped with special chaff collecting trailers. This gives the *(Continued on page 354)*

This paper was prepared expressly for AGRICULTURAL ENGINEERING.

Hans Sack was formerly technical manager of the Rud. Sack Implement Works, Leipsig, Germany, and is now working independently in the development and manufacture of farm equipment in that country.



Universal flexible harrow with three tooth sizes

Irrigation of Corn in the Piedmont

By Joe B. Richardson
Member A.S.A.E.

IN 1946 an investigation of the influence of moisture applied by high-pressure sprinkler irrigation on corn yields was initiated. Approximately two acres of Hiawassee sandy loam soil which had been planted to truck crops in 1945 was selected for the investigation.

The plots were plowed during the fall of 1945 and lay fallow until planting time. Before corn was planted 1400 lb per acre of a 4-10-6 fertilizer was applied to 42-in rows with a two-row tractor planter and fertilizer drill, after which the land was disked lightly. On April 8, the corn was planted with the two-row planter at which time an additional 700 lb of a 4-10-6 fertilizer per acre was applied. The variety of corn planted was Funk's hybrid G-714, which was drilled in each plot at two spacings of 9 in and 18 in each. Germination was good and no apparent fertilizer damage to seed or plants was noticeable.

Early growth was rapid and two cultivations were complete on May 24 when the corn was approximately 28 in high. Nitrogen at the rate of 100 lb per acre was side-dressed in the form of ammonia nitrate on June 19, and an additional 100 lb per acre as cal-nitro on July 11.

Distribution of the water was obtained by a small centrifugal pump and ten No. 20 Skinner sprinklers on 10-ft risers spaced at 20-ft intervals along the line.

In 1947 the corn irrigation was continued on the same area used in 1946. However, a cover crop of vetch and rye followed the corn. High rainfall in April delayed the plowing under of the cover crop until the rye had made heavy growth and the heads were near the milk stage, while the vetch was beginning to bloom. The green manure crop was turned under April 22, and on April 23, 2200 lb of 20 per cent cyanamid was broadcast over the plots with a grain and fertilizer drill. Several diskings followed at intervals until May 23 when 1400 lb of a 4-10-6 fertilizer per acre was applied broadcast with grain and fertilizer drill. With a two-row tractor planter and fertilizer drill 700 lb more per acre of a 4-10-6 fertilizer was applied as the corn was planted in 42-in rows spaced 13 in in the drill.

With heavy applications of fertilizers, it seem advisable to increase the number of plants per acre. Small plots were selected in both the irrigated and non-irrigated areas and interplanting was done, which resulted in corn planted in 21-in rows.

Although rainfall had been rather light during May, and especially since the cover crop was turned under, germination was good and corn grew rapidly. Cultivation was completed on June 27, at which time 250 lb of muriate of potash per acre was applied.

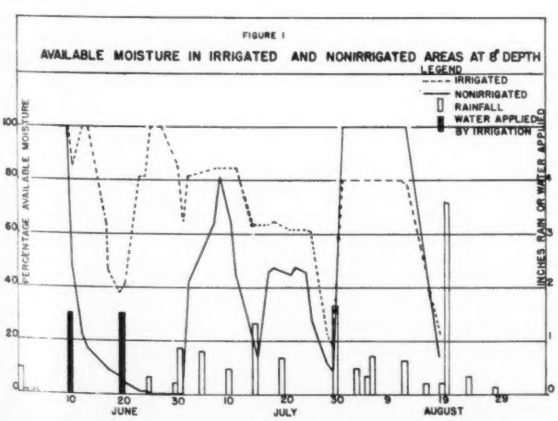
The soil moisture requirements for plant growth were based on Bouyoucos electrical resistance blocks which were installed at intervals throughout the plots and at depths 8, 18, and 24 in by scientists of the Soil Conservation Service. All irrigations were on the basis of the block readings at 8-in depth. Moisture availability throughout the growing season at the 8-in depth recorded is shown in Fig. 1. During the 1946 season, it was necessary to make two supplemental irrigations, the first on June 11 and the second on June 21. Approximately 1.50 in of water was applied each time at the rate of 0.40 in per hr, which is approximately the infiltration rate of the soil. The pump used in 1946 had only sufficient capacity for the operation of ten No. 20 sprinklers equipped with 7/32-in nozzles. Therefore, 3 to 4 days were required to cover the total area irrigated. No exact checks were made on the distribution pattern of the No. 20 sprinklers; however, it appeared to be uniform within the radius of spray.

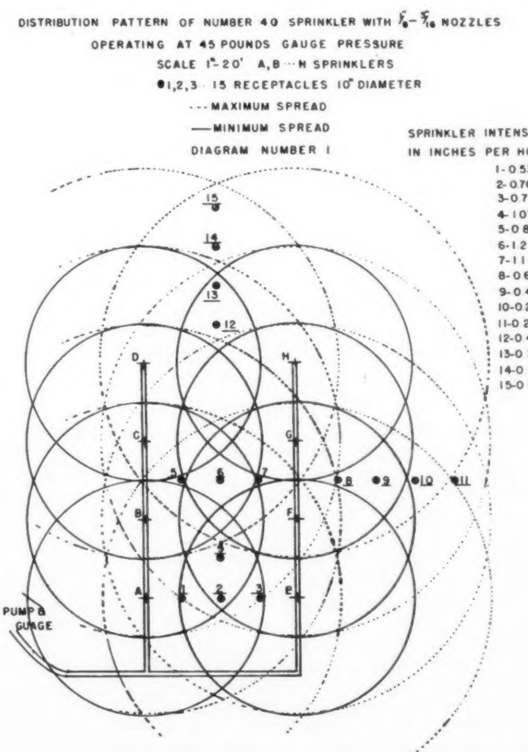
For the 1947 crop a pump was used which had sufficient capacity to cover the entire area irrigated. No. 40 sprinklers equipped with 1/8 x 3/16-in nozzles were set at 40-ft intervals along the distribution lines which were also spaced 40 ft apart. During the operation of the system the question arose as to uniform rate delivered from the minimum and maximum radius pattern of the No. 40 sprinkler operating at 45 lb gage pressure.

Based on data published by the manufacturer, the No. 40 sprinkler equipped with 1/8 x 3/16-in nozzles operating at 45 lb gage pressure distributes approximately 10 gpm. From this information, it was calculated to deliver 0.40 in of water per

This paper was presented at a meeting of the Southeast Section of the American Society of Agricultural Engineers at Washington, D. C., February, 1948.

JOE B. RICHARDSON is associate agricultural engineer, Clemson Agricultural College.





hour per acre when operating 18 sprinklers, which were a sufficient number to cover one acre, spaced as recommended by the producers. On July 14, after 2½ hrs operation at 45 lb gage pressure, no accumulation of water or runoff occurred; however, after 3½ hrs operation on July 15, considerable ponding of water was noticeable and runoff was occurring at most outlets. In later irrigations operating at 37 lb gage pressure it appeared that distribution was not uniform within the radius of spray; catch basins placed within the patterns confirmed these observations. Recording of the Bouyoucos blocks further confirmed that the soil had not been wet equally throughout the irrigated plots.

In view of the above observation further checks were made on the No. 40 sprinklers operating at different gage pressures and using different size nozzles. The sprinkler interval was changed from 40 ft to 20 ft and only eight nozzles were operating (Diagram 1). The receptacles were 10 in in diameter and set 10 ft apart around the sprinklers. Operating periods were for 30 min and only one check was made, which is not sufficient for accurate and conclusive data; however, the intensity should be comparative.

The yields for silage and shelled corn, based on 15 per cent moisture, for the years 1946 and 1947, are as shown in Table 1. Although the corn yields on irrigated plots for 1946 are approximately 30 bu higher than for 1947, there was less variation in test samples in 1946 than in 1947. Yields on non-irrigated plots in 1946 were approximately 100 bu greater per acre than yields on non-irrigated plots for 1947. The high yields on non-irrigated plots in 1946 were due to high rainfall during growing season. In retrospect the low yields on non-irrigated plots for 1947 was due possibly to low rainfall during the growing season. Available moisture at 8 in depth in non-irrigated plots was near zero from July 20 until about September 10.

TABLE 1. GRAIN AND SILAGE YIELDS FROM IRRIGATED AND NON-IRRIGATED CORN

Treatment	Spacing in drill, in	Corn yield, bushels per acre		Silage yield, tons per acre	
1946			Average		Average
Irrigated	9 *	137		37	
			138		34
	18 *	138		31	
Nonirrigated	9 *	109		25	
			113		24
	18 *	116		23	
1947					
	13 *	110		35	
Irrigated			110		36
	13 †	83	83	37	
Nonirrigated	13 *	22		16	
			22		16
	13 †	14		16	
			14		

* Rows were 42 in apart.
† Rows were 21 in apart.

OBSERVATIONS

The corn was planted on an area above average in fertility. Fertilizers were applied in 1946 in the following amounts: 284 lb nitrogen, 210 lb phosphoric acid, and 126 lb potassium oxide; or plant nutrients sufficient to produce 180, 362, or 108 bu of corn, respectively, depending on which element acted as the limiting factor. However, the maxium yields were not as high as expected. Disregarding the value of cover crop turned under or any fertilizer residue from 1946, fertilizers for production of the 1947 crop were applied in the following amounts: 304 lb nitrogen, 210 lb phosphoric acid, and 250 lb of muriate of potash, or enough to produce 190, 362, or 222 bu of corn, again depending on which element may have been the limiting one. Nitrogen should have been the limiting factor in 1947; however, yields were 80 bu less than maximum expected. Average yields on irrigated plots for the two years are six times the state average. Greater yields may be possible when more is known about the optimum growth requirement for corn.

Results for two years indicate that yields of shelled corn are not increased when total plants per acre are greater than 12,000. Silage yields were appreciably increased when total plants were increased beyond 12,000. It is probable that breeders of corn varieties were not thinking in terms of 200 to 300 bu per acre when selecting approved strains. However, there may be untried varieties which would approach such yields under similar conditions. There are numerous factors, such as soil structure, texture, acidity, or lack of air or carbon dioxide which may limit higher yields. In any event, it does not appear that soil moisture or applied plant nutrients were the limiting factors in the irrigated plots.

However irregular the distribution of water may have been, it appears that lack of uniformity in total available moisture did not effect maximum yields. Many tests have been made on various types of sprinklers, yet there seems to be greater need for more thorough testing of our sprinklers as to best layout arrangements, spacing of distribution lines, spacing of various sprinkler sizes, and pressures at which most efficient results can be obtained.

New Sugar Beet Harvester

(Continued from page 351)

of only 5 per cent under similar conditions. In wet soils, average dump screenings have been reduced to 5.7 per cent, with only moderate damage to the roots. This compares favorably with most commercial harvesters.

The worst feature of the lifting unit is the use of mechanically undesirable means to accomplish the desired results. The operation of chains in a shower of soil is difficult, and the problems incident thereto have been only partially solved. This lifting device does, however, appear worthy of further trial and development. It is the only device which has so far appeared which shows promise of harvesting topped beets under all soil moisture conditions. It is also the only pickup mechanism which leaves missed beets in plain view on the ground surface.

The hopper-loader has proved to be entirely satisfactory as a method of handling harvested beets.

CONCLUSION

This report describes only one phase of the sugar beet harvester investigations which have been carried on at the University of California. A more complete account of the project has been prepared by its director[2].

The harvester which has been described is not a practical machine in its present form. Mechanical refinement, particularly in the lifting mechanism, is necessary if the machine is to be of interest to a farmer. First, however, extensive field trials with the present machine are desirable to observe its performance under different field conditions.

REFERENCES

1 Powers, J. B. Basic principles used in the design of a beet topper. Proc. Am. Soc. Sugar Beet Technologists. Part II, pp. 266-73, 1940.

2 Walker, H. B. A resume of sixteen years of sugar beet machinery research. Proc. Am. Soc. Sugar Beet Technologists. 1948, in print.

Weed Control with Flexible Harrow

(Continued from page 352)

German farmer the dual advantage of collecting the chaff for feeding purposes and of keeping the field free from weed seed.

With the high price of labor in the United States it would be impossible to complicate the combining of grain with the gathering of chaff. Therefore, it seems doubly important to use simple methods to control weeds, to conserve moisture, and to improve the soil structure in the grain-growing districts where weeds are a problem. I would be glad to check the economic possibilities of the application of the flexible harrow in the United States, in order to increase food production for the benefit of our hungry world.

Effect of End Flares on Capacity of Irrigation Siphon Tubes

By R. H. Dubois
Junior Member A.S.A.E.

THE use of short plastic, rubber, or metal tubes for siphoning water from irrigation ditches into furrows is favored over other methods of water distribution by many irrigators. The method facilitates uniform distribution of water, since all tubes of a given size and material will discharge the same quantity of water when operating under the same head. By having a knowledge of the capacities of his siphons, it is possible for an irrigator to control the quantity of water which he applies within quite accurate limits.

It is possible to increase the capacity of a given size of siphon tube by flaring the ends to decrease the entrance and exit losses. Brackett[1]* and Larsen reported that good results are obtained if the inside diameter of the flared end measures about 25 per cent greater than the tube diameter. Johnston[2] found that a conic section about 9 in long and with a mouth diameter approximately equal to three times the tube diameter gave significant increases in flow. Russell[3] conducted a series of experiments using diverging tubes 1.22 in in diameter and heads of 0.5 to 1.6 ft, and found that (a) discharge increases as the length of the flare increases and (b) the maximum discharge was obtained with flares of from 7 to 10½ deg.

The object of the investigation reported herein was to determine the most efficient angle and length of flare which can be applied to irrigation siphon tubes. Aluminum tubes were used for the tests. The tubes had no joints, having been manufactured by bending extruded aluminum tubing to the desired shape, and were smoothly finished inside. Tests were conducted on the tubes as they came from the manufacturer with the ends straight; then with the inlet end flared, outlet end flared, and with both the inlet and outlet ends flared. The tubes were 4 ft in length, and when a flare was added, the tube was shortened by an amount equal to the length of the flare, so that in all tests the tube plus the conical section was 4 ft in length. The flares were attached by welding the conic section to the tube, after which the joint was carefully finished to a smooth surface.

This paper was prepared expressly for AGRICULTURAL ENGINEERING.

R. H. DUBOIS, formerly assistant professor of agricultural engineering at Kansas State College, is now engaged in farming at Burlingame, Kansas.

*Superscript numbers refer to appended references.

The tests which were conducted included angles of flare of 3 and 10 deg, with a length of 1, 3, and 6 in, and 90 deg for a length of 1 in and 3 in. The outlet end of the tube was submerged in all tests, and the head was measured as the difference between the elevations of the water surface at the inlet and outlet ends of the siphon.

Due to ease of construction, the same sizes and shapes of conical sections were used on the inlet ends of the metallic siphons. The plastic tubes were flared by heating the end of the tube until soft. The flare was then formed by inserting a block of hardwood into the end, expanding the end of the tube to the desired diameter. The shape of the form block and the shape of the ends of the plastic tubes when formed in this manner is shown in Fig. 1, and the shape and dimensions of the metallic tubes are shown in Fig. 2.

The first tests were designed to determine the effect of the length of flare on capacity of the siphons, the angle remaining constant. The results of this test are shown in Table 1. A study of this table reveals that

1 In every case the discharge is increased by flaring either or both the inlet or outlet end.

2 In every case the flared inlet end increased the discharge at least as much and in most cases more than the flared outlet.

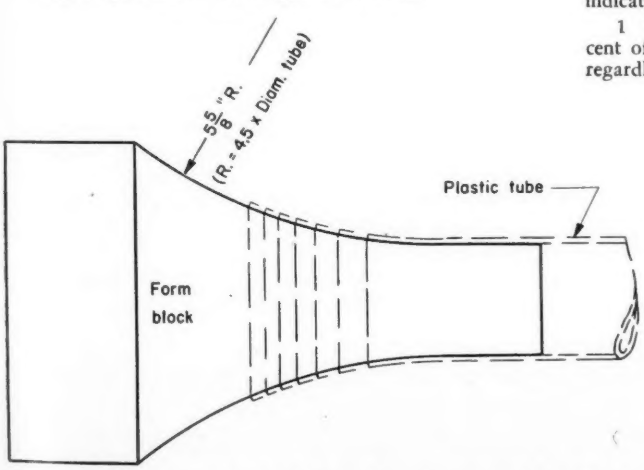
3 In every case the tubes which had both ends flared had an increase in capacity approximately equal to the sum of the increases caused by inlet and outlet flares when used individually.

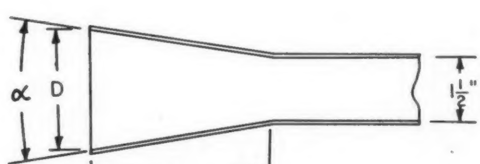
4 In all cases, with a given angle of flare, the capacity increased with an increase in length.

The next tests indicate the effect of angle of flare on capacity, the length of flare remaining constant. The results of the tests are shown in Table 1. These data indicate that, with the lengths of flares used, an angle of 10 deg gave the greatest increase in capacity.

An analysis of the data on the basis of percentage increase in flow created by the various arrangements of flare lengths and angles is shown in Fig. 3. For this purpose, only the data obtained by having both the inlet and outlet ends flared were used, since this condition gave the maximum increase in discharge. An analysis of the data shown in Fig. 3 indicates the following:

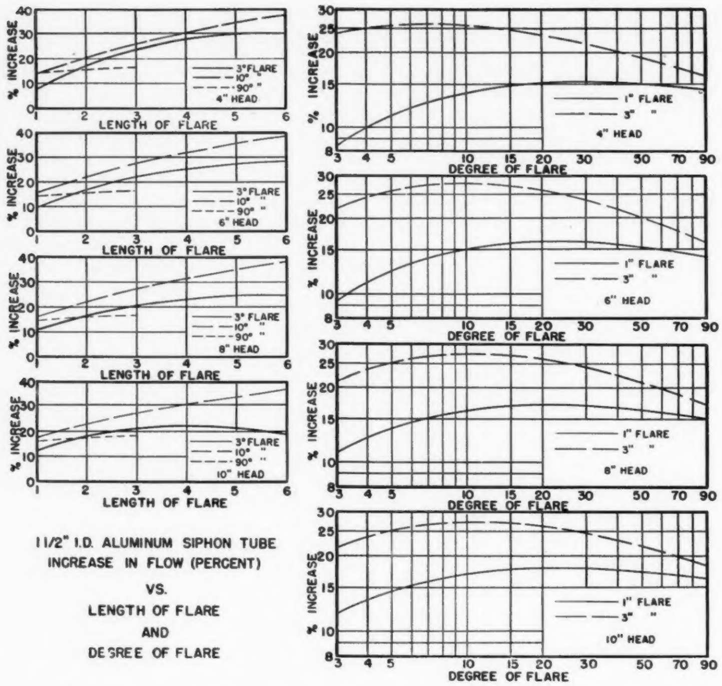
1 With a length of flare of one inch the maximum per cent of increase in flow occurs with a flare angle of 10 deg, regardless of the head.





α	3°			10°			90°		
L	1"	3"	6"	1"	3"	6"	1"	3"	—
D	1.55"	1.66"	1.81"	1.68"	2.03"	2.56"	3.50"	7.50"	—

Fig. 1 (*Left*) A form block for forming flares on plastic tubes • Fig. 2 (*Right*) Dimensions of flares used on metal siphon tubes



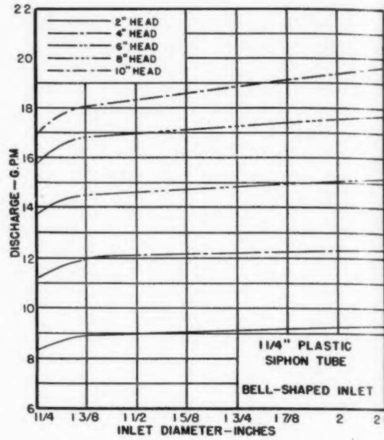


Fig. 3 (*Left*) This series of graphs shows the percentage increase in flow created by the various arrangements of flare lengths and angles • Fig. 4 (*Above*) This graph shows how the inlet diameter of a 1¼-in plastic tube (with bell-shaped inlet) affects the discharge rate

2 With a length of flare of 3 in, the maximum per cent of increase in flow occurs with a flare angle of approximately 20 deg, regardless of the head.

3 With a flare angle of 3 deg, the per cent of increase in flow becomes greater, at nearly a constant rate, as the length of flare increases.

4 With a flare angle of 10 deg, the per cent of increase in flow becomes greater as the length of flare increases. However, the rate at which the per cent of increase in flow becomes greater, decreases with an increase in head, until the tubes when operating under a head of 10 in show a maximum increase in flow with a length of flare of 4 in.

5 With a flare angle of 90 deg, there is no significant change in the per cent increase in flow caused by increasing the length of flare, regardless of the head.

TABLE 1. RATE OF FLOW OF 1½-IN ALUMINUM SIPHON TUBES WITH VARIOUS FLARES AND OPERATING UNDER VARYING HEADS

Inlet end Flare		Outlet end		Rate of flow, gal per min Head, inches				
Degree	Length, in	Degree	Length, in	2	4	6	8	10
0	0	0	0	11.8	16.7	20.5	23.8	26.7
3	1	0	0	12.3	17.8	21.9	25.6	29.0
0	0	3	1	12.3	17.8	21.9	25.6	29.0
3	1	3	1	12.9	18.1	22.4	26.4	30.0
3	3	0	0	12.6	17.9	22.1	25.9	29.4
0	0	3	3	12.6	17.9	22.1	25.9	29.4
3	3	3	3	14.3	20.7	25.0	28.8	32.6
3	6	0	0	13.9	18.8	23.1	27.0	30.8
0	0	3	6	11.9	17.4	21.5	25.0	28.3
3	6	3	6	15.1	21.8	26.3	29.8	31.9
10	1	0	0	11.9	17.6	21.9	25.8	29.3
0	0	10	1	11.8	17.2	21.3	25.0	28.4
10	1	10	1	12.8	19.0	23.6	27.7	31.4
10	3	0	0	12.3	18.3	22.7	26.6	30.1
0	0	10	3	12.4	18.4	22.8	26.7	30.3
10	3	10	3	14.5	21.0	22.2	30.3	34.1
10	6	0	0	12.5	18.7	23.2	27.1	30.7
0	0	10	6	12.5	18.7	23.2	27.1	30.7
10	6	10	6	15.0	23.2	28.5	32.9	36.8
90	1	0	0	14.2	19.4	23.4	27.1	30.4
0	0	90	1	12.8	17.8	21.5	24.6	27.5
90	1	90	1	14.0	19.1	23.4	27.4	31.2
90	3	0	0	13.2	18.8	23.2	27.1	30.7
0	0	90	3	11.9	17.1	21.2	24.6	27.8
90	3	90	3	13.8	19.4	23.8	27.9	31.7

Results of investigation of plastic tubes with rounded inlets are shown in Fig. 4. From this data, it can be observed that the discharge can be increased by the use of the type of inlet shown in Fig. 1. However, it may be noted that the greatest amount of increase is caused by the first expansion of ⅛ in. Thereafter, with further enlargement, the capacity of the tubes is increased by a maximum amount of 15 per cent when expanded to 2⅛ in and operating under a head of 10 in.

CONCLUSIONS

1 Flaring only the inlet end of a siphon tube will increase its capacity by 9 to 15 per cent. A flare angle of either 3 deg or 10 deg, with a length of 6 in, gives an increase of 15 per cent.

2 Flaring only the outlet end of a siphon tube will increase its capacity by 3 to 15 per cent. A flare angle of 10 deg, with a length of 6 in, gives an increase of 15 per cent.

3 Flaring both the inlet and outlet ends of a siphon tube will increase its capacity by 12 to 39 per cent. A flare angle of 10 deg, length of 6 in, gives an increase of 39 per cent.

4 The per cent of increase in flow, in general, becomes greater as the heads increase.

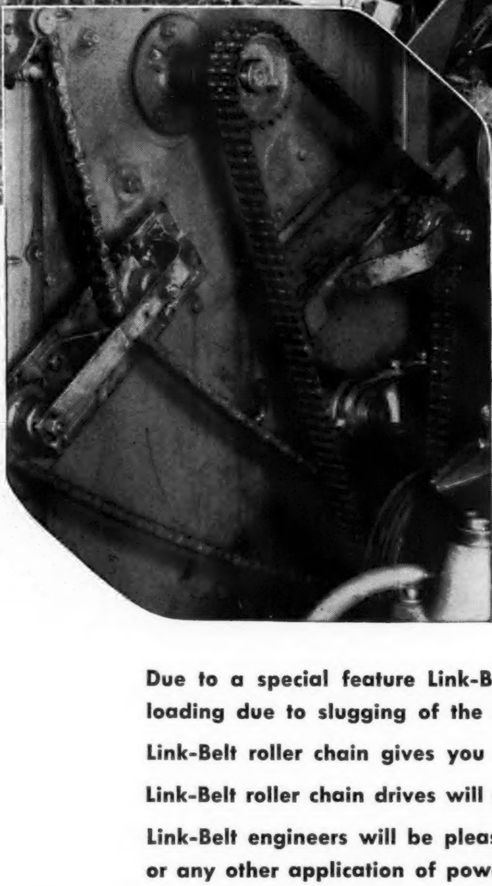
5 If a flare length of 3 in is used, the angle of flare should be between 10 and 20 deg.

REFERENCES

1 Brackett, E. E., and Larsen, L. F. Rates of Flow for Irrigation Siphon Tubes. The Agricultural Engineer, Information Series No. 16. Extension Service, College of Agriculture, Univ. of Nebraska, July 1944.

2 Johnston, C. N. Comparison Performances of Metallic and Plastic Siphons for Irrigation, AGRICULTURAL ENGINEERING, October, 1946.

3 Russell, George E. Hydraulics, fifth edition, Henry Holt and Co., 1946, pp. 468.



NEWS SECTION

A.S.A.E. Meetings Calendar

September 8-10 — North Atlantic Section, Ontario Agricultural College, Guelph, Ont., Canada.

October 21 and 22 — Pacific Northwest Section, Columbia Gorge Hotel, Hood River, Ore.

December 13-15 — Winter Meeting, Stevens Hotel, Chicago.

June 20 to 23 — Annual Meeting, Michigan State College, East Lansing, Mich.

Easter First Chairman of New Alabama Section

MEMBERS of the American Society of Agricultural Engineers in the State of Alabama honored E. C. Easter, manager, rural and towns division, Alabama Power Company — and a past-chairman of the ASAE Rural Electric Division and a former member of the ASAE Council — when it elected him chairman of the new Alabama Section of the Society at its organization meeting held at the Pitts Hotel in Auburn on June 11.

The meeting was presided over by Temporary Chairman Fred A. Kummer, recently appointed head of the agricultural engineering department of Alabama Polytechnic Institute. There were 22 members of the Society present, and following announcement that the petition of members of the Society in Alabama to the Council for authorization to organize the Section had been approved, the group proceeded to the work of organization.

Chairman Kummer appointed a nominating committee consisting of J. B. Wilson, Harry Dearing, and I. F. Reed. The slate of new officers for the Section, selected by the committee, was unanimously adopted and included, in addition to Mr. Easter, William A. Womack, owner, Rocky Creek Farms, Ashford, Ala., as the Section's first vice-chairman. Harry B. Pfost, assistant professor of agricultural engineering, A.P.I., was elected secretary-treasurer.

During the business session, the group voted to hold at least two meetings of the Section each year, one of which will be held at Auburn. More than two meetings may be held at the discretion of the executive committee.

Giles New AE Head at North Carolina

ANNOUNCEMENT has been made of the appointment of Prof. G. Wallace Giles as the new head of the agricultural engineering department at North Carolina State College, succeeding Davis S. Weaver, who was named assistant director of the North Carolina Extension Service on January 1.

Recent additions to the agricultural engineering staff include Ira L. Williams, instructor in farm machinery; E. N. Scarborough, research in farm machinery; Paul E. Green, Jr., research in tobacco curing, and Sidney H. Usry, research in crop processing.

Bainer on Mission to Japan

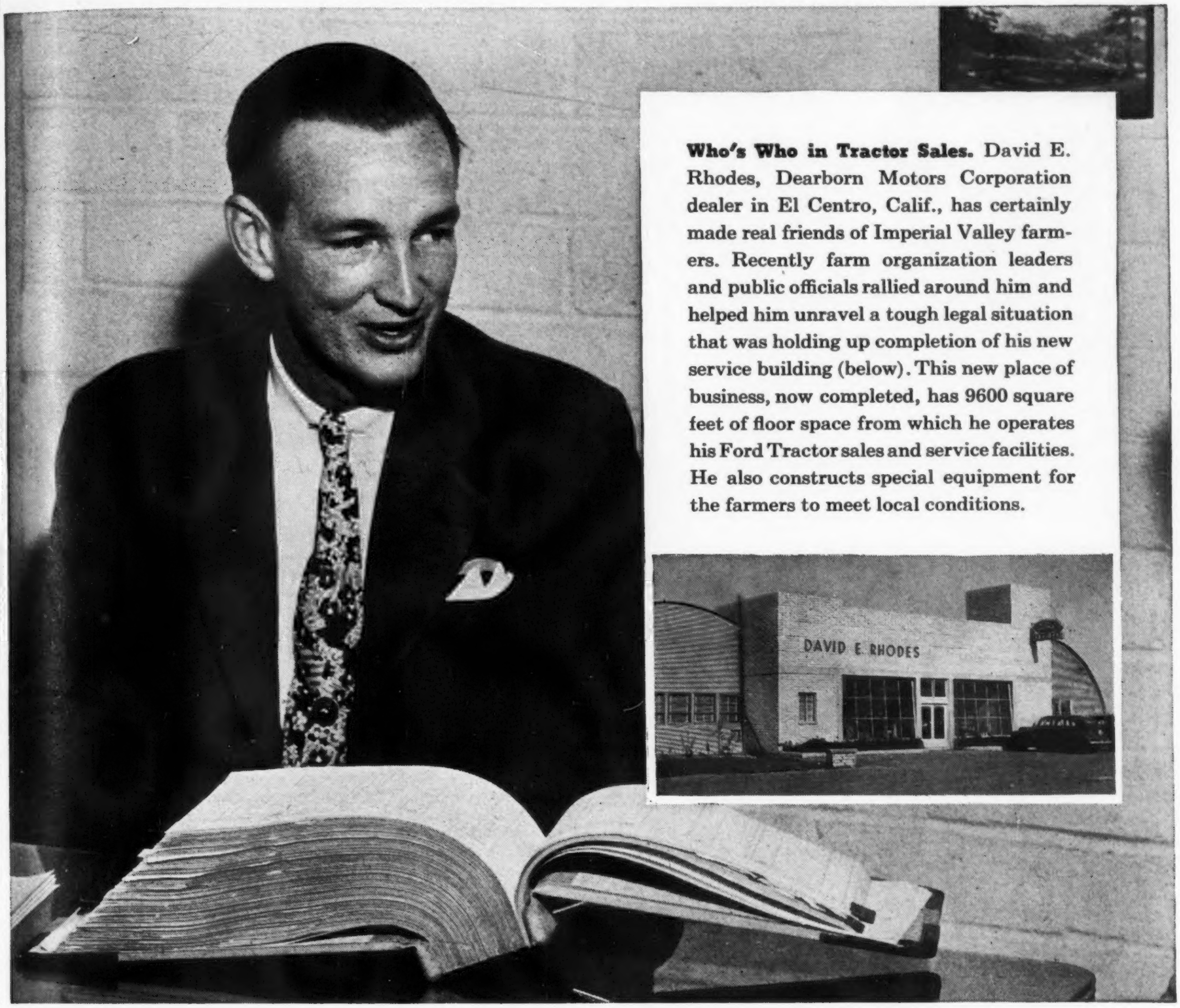
AT the special request of Gen. Douglas MacArthur's headquarters in Japan to Washington, Roy Bainer has been granted a three months' leave as head of the agricultural engineering division of the University of California at Davis, to serve as agricultural engineering consultant to the U. S. Army. His duties will be to study the type of agricultural tools and machinery now commonly used by farmers in Japan and make recommendations as to new types of equipment or improvements in design of present equipment which will enable farmers of that country to increase production.

Nominations for A.S.A.E. Medal Awards

IN ACCORD with the rules governing the award of the John Deere and Cyrus Hall McCormick Gold Medals, the Jury of Awards of the American Society of Agricultural Engineers will receive from members of the Society, up to November 1, nominations of candidates for the 1948 awards of these two medals.

Members of the Society nominating candidates for either award are requested to keep in mind the purposes of each medal and make their nominations accordingly. The John Deere Medal is awarded for "distinguished achievement in the application of science and art to the soil," which citation is interpreted to cover more than a mechanistic concept of engineering, and to include chemistry, physics, biology, and any other science and art involving the soil, the "application" being acceptable to "evaluation by the engineering criteria of practicality and economic advantage."

The Cyrus Hall McCormick Medal is awarded "for exceptional and meritorious achievements of a continuing career or to any single item of engineering achievement, and to apply equally to all special fields and types of engineering in agriculture." *(Continued on page 360)*



Who's Who in Tractor Sales. David E. Rhodes, Dearborn Motors Corporation dealer in El Centro, Calif., has certainly made real friends of Imperial Valley farmers. Recently farm organization leaders and public officials rallied around him and helped him unravel a tough legal situation that was holding up completion of his new service building (below). This new place of business, now completed, has 9600 square feet of floor space from which he operates his Ford Tractor sales and service facilities. He also constructs special equipment for the farmers to meet local conditions.

"High compression saves work . . . means more income per acre for my customers,"

says David E. Rhodes, Dearborn Motors Corporation dealer of El Centro, California

"We've been pushing high compression tractors here in Imperial Valley ever since we went into business. High compression is a natural for us. With tough land to cultivate—plus Southern California's special irrigation problems, which call for plenty of ditch digging and similar work—our customers really need all the extra power that high compression engines deliver.

"High compression engines give farmers *more power, greater economy, quick starting, fast warm-up, smooth idling* and *clean burning* of fuel," continues Mr. Rhodes. "Our gasoline-operated Ford tractors help farmers work more acres per day, get their work done on time and get more income out of every acre."

In all forty-eight states, tractor dealers such as Mr. Rhodes are recommending high compression. These dealers are helping farmers by encouraging them to use the kind of tractor and fuel that will do the best job. Today eight out of ten farmers prefer gasoline. And more than eighty per cent of the tractors being manufactured have high compression engines. *Ethyl Corporation.*

NEWS SECTION

(Continued from page 358)

The Jury of Awards desires that members of the Society consider it their duty and obligation to give serious thought to the matter and nominate for either or each of these awards the men they believe to be most worthy of the honor. Each nomination must be accompanied by a statement of the reasons for nominating a candidate and qualifications of the nominee, including his training, experience, contributions to the field of agriculture, a bibliography of his published writings, and any further information which might be useful to the Jury in its deliberations.

The Jury will accept and consider nominations received on or before November 1, and these nominations should be addressed directly to the Secretary of the Society at St. Joseph, Michigan. The Secretary will supply on request a standard set of instructions for preparing information in support of nominees for the Society's gold medal awards; in fact, it is important that these instructions be followed in preparing material on behalf of any nominee.

Fertilizer Application Program

THE NEXT annual meeting of the National Joint Committee on Fertilizer Application will be held at the Gibson Hotel, Cincinnati, Ohio, on September 8. The Committee is comprised of representatives of five national organizations—American Society of Agronomy, American Society for Horticultural Science, National Fertilizer Association, Farm Equipment Institute, and American Society of Agricultural Engineers.

The program for the forenoon session will open with a discussion of the work of the National Joint Committee on Fertilizer Application in relation to horticultural science by Dr. A. L. Schrader of the Maryland Agricultural Experiment Station. Dr. W. P. Judkins of the Ohio Agricultural Experiment Station and Dr. J. B. Hester of the Campbell Soup Company will discuss, respectively, evaluations of fertilizer practices on tree and small fruit crops and on vegetable crops. The role of radioactive isotopes and other new techniques in evaluating fertilizer practices is the subject of a talk by Dr. F. W. Parker of the U. S. Department of Agriculture. General discussion will conclude the session.

The afternoon program will include three papers, opening with one on an application of nutrients to the aboveground parts of plants to correct deficiencies by Dr. D. I. Arnon of the California Agricultural Experiment Station. This will be followed by one on the soilless culture method of supplying the nutrient requirements of plants by Dr. O. W. Davidson of the New Jersey Agricultural Experiment Station. R. M. Merrill, agricultural engineer, Deere & Co., and representing the Farm Equipment Institute, will discuss fertilizer application equipment as the third number on this program.

Following these papers a panel of speakers will discuss the role of legume and non-legume cover crops, and sod and hay crops, and their fertilization in rotations to improve soil structure and fertility. The panel will consist of Kirk Fox, editor, Successful Farming; B. A. Krantz, North Carolina Agricultural Experiment Station; D. R. Dodd, Ohio Agricultural Experiment Station; E. H. Tyner, West Virginia Agricultural Experiment Station; G. N. Hoffer, American Potash Institute; J. D. Warner, North Florida Agricultural Experiment Station; G. R. Muhr, Minnesota Valley Canning Company; H. H. Tucker, Coke Oven Ammonia Research Bureau, and M. H. McVickar, the National Fertilizer Association. General discussion will follow.

A past-president of ASAE—Arthur W. Turner, assistant chief (in charge of the agricultural engineering divisions) of the USDA Bureau of Plant Industry, Soils, and Agricultural Engineering—is serving this year as general chairman of the National Joint Committee on Fertilizer Application. The secretary of the Committee is Dr. F. S. Lodge, acting president of the National Fertilizer Association.

N.F.E.C. Meets in November

THE THIRD annual National Farm Electrification Conference will be held November 17, 18, and 19, at the Congress Hotel, Chicago, Ill. The program will feature forum discussions and addresses by top level speakers in such fields as industry, government, agriculture, education and publishing. Among outstanding speakers scheduled for addresses is Congressman Clifford F. Hope of Kansas, chairman of the Agricultural Committee of the House of Representatives. The 1948 program is under direction of Geo. A. Rietz, manager, farm industry division, General Electric Co.

To strengthen the Conference organization, six regional vice-chairmen have been added to the official governing board or steering committee. They are: R. B. Corbett, College Park, Md., associate dean and associate director, college of agriculture, University of Maryland; J. B. Rodgers, Corvallis, Ore., head, agricultural engineering department, Oregon State College; P. D. Sanders, Richmond, Va., editor of "Southern Planter" and master of the Virginia State Grange; P. T. Montfort, College Station, Texas, research associate in agricultural engineering, A. & M. College of Texas; H. E. Slusher, Jefferson City, Mo., president, Missouri Farm Bureau Federation, and E. G. Stahl, San Francisco, Calif., manager, agricultural sales, Pacific Gas & Electric Co.

(News continued on page 362)


U.S. ROYAL FARM TRACTOR

SAE Tractor Meeting Program

THE first combined National Tractor and Diesel Engine Meeting of the Society of Automotive Engineers will be held September 7 to 9 at the Hotel Schroeder, Milwaukee, Wis. The 13 technical papers comprising the program include such subjects as the following: cathode ray studies of diesel combustion, improved engine design effected by a diesel fuel test program, research in Holland on lower cost diesel fuels, influence of fuel consumption on engine deposit formation in high-speed diesel engines, relation of rated load capacity to pay load in earthmoving equipment, piston ring and cylinder wear research, hydraulic and planetary transmissions, power losses in tractor engines, effective use of high octane fuel, and a new testing machine for tractor tires. There will also be a dinner address on future power plants for tractors and road machinery.

"D-D," a Shell Registered Trademark

TO THE EDITOR:

In the July, 1948, issue of AGRICULTURAL ENGINEERING there appeared an article by John E. Carreker and W. J. Liddell, entitled "Results of Irrigation Research in Georgia — Part II," which reported on studies made in 1947 relating to the use of soil fumigants for nematode control.

While we were very well impressed by the authors' work and pleased with the favorable results reported for our product, "D-D", we were somewhat concerned by the repeated designation throughout the article of a competitor's soil fumigant as "Dow D-D". We therefore feel compelled to bring to your attention the fact that "D-D" is a Shell Chemical registered trademark, bearing Federal Registration Number 411,371, granted January 16, 1945, which date was some time before the work reported in your journal was begun. In addition, this trademark has been registered in many states including all the southeastern area. The registration date in Georgia was July 24, 1945.

J. OOSTERMEYER.

President, Shell Chemical Corp.

New Literature

HEATING, VENTILATING, AIR CONDITIONING GUIDE, 1948, (26th edition). Leatherette, xxiv+1280+144 pages. Illustrated and indexed. American Society of Heating and Ventilating Engineers (New York 10, N.Y), $7.50.

Technical data section, catalog data section, and roll of membership. The technical data section has 51 chapters grouped under 8 section headings including principles, human reaction to atmospheric environment, heating and cooling loads, combustion and consumption of fuels, heating systems and equipment, air conditioning, special applications, and installation and testing codes.

Applicants for Membership

The following is a list of recent applicants for membership in the American Society of Agricultural Engineers. Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.

Baker, H. Harlan—Agricultural engineer (rural service), Northern Illinois Utilities Co. (Mail) 421 W. First, Dixon, Ill.

Bartling, Loren E.—Research and development engineer, Dearborn Motors Corp. (Mail) 3223 N. Adams Rd., Birmingham, Mich.

Bond, Theodore E.—Junior agricultural engineer, U. S. Department of Agriculture. (Mail) 313 E. St., Davis, Calif.

Brown, Kenneth R.—Owner and chief engineer, Brown Engineering Co. (consulting engineers), 322-334 K. P. Bldg., Des Moines, Iowa.

Buresh, Ernest J.—Sales engineer, Clay Equipment Corp., Cedar Falls, Iowa. (Mail) R. R. No. 2.

Burgener, Maurice L.—Assistant in agricultural engineering research, University of Illinois. (Mail) 118 E. Garwood, Champaign, Ill.

Calienes, Raul F.—Agricultural manager, "San Jose del Lago", Mayajigua, Las Villas, Cuba.

Canady, M. E.—Junior engineer, United Irrigation Co., Mission, Tex. (Mail) General Delivery.

Chanfreau, G. R.—Professor, Escuela Superior De Agricultura "Antonio Narro", Saltillo, Coahuila, Mexico.

Drayton, Frank J.—Supervisor of implement sales, Dearborn Motors Corp., Detroit, Mich. (Mail) 9316 Steel.

Eagleton, Robert H.—Agricultural engineering dept., University of Illinois. (Mail) Noble, Ill.

Everett, Henry B.—Agricultural engineer, California Redwood Assn. (Mail) 612 Balra Dr., El Cerrito, Calif.

Forth, Murray W.—Assistant in agricultural engineering research, University of Illinois, Urbana, Ill.

Francis, Ronald L.—Engineer, Dominion Department of Agriculture. (Mail) P. O. Box 377, Taber, Alta., Canada. *(Continued on page 364)*

Applicants for Membership

(Continued from page 362)

Fuhrman, Dean K.—Agricultural engineer (research), Soil Conservation Service, USDA. (Mail) Federal Experiment Station, Mayagues, Puerto Rico.

Geerts, A. J.—Manager, farm equipment div., export dept., Montgomery Ward & Co. (Mail) 219 N. Hamilton, Gary, Ind.

Handley, Thomas B.—Agriculturist, U. S. Bureau of Reclamation, USDI. (Mail) P. O. Box 1269, Visalia, Calif.

Hart, Charles W., Jr.—Junior design engineer, Towner Mfg. Co. (Mail) 505 E. Whiting Ave., Fullerton, Calif.

Hotchkiss, Kenneth W.—Malcolm, Nebr.

Innes, Don W.—President, Innes Co., Bettendorf, Iowa.

Johnson, Joe C.—Trezevant, Tenn.

Juzwik, E. A.—President and chief engineer, Power Production Co., 10 S. LaSalle St., Chicago, Ill.

Kambour, Theodore—Work group engineer (civil), Soil Conservation Service, USDA. (Mail) 18 S. Main St., Lancaster, N. H.

King, William N., Jr.—P. O. Box 70, North Hollywood, Calif.

Larson, Russell E.—Junior agricultural engineer, Bureau of Plant Industry, Soils and Agricultural Engineering, USDA. (Mail) Agricultural Engineering Bldg., University Farm, St. Paul 1, Minn.

Lucas, Lawrence M.—Junior engineer, Niagara Chemical Div., Food Machinery Corp. (Mail) 918 Gwinn St., Medina, N. Y.

Martz, Charles L.—Swift and Co., Chicago, Ill. (Mail) 3330 W. Polk St.

Maybin, A. H., Jr.—Instructor, Long Island Agricultural & Technical Inst., Farmingdale, N. Y.

McDowell, Q. J.—Combine specialist, Dearborn Motors Corp., Detroit, Mich. (Mail) 18303 Appoline Ave.

McGuire, Dennis—Rural service representative, Consumers Power Co., Owosso, Mich.

Morgan, M. J.—Salesman, Holt Equipment Co., Weslaco, Tex.

Mury, Eugene L.—Sales manager, Coastal Machine Works, Inc., 113 E. Washington Ave., Bridgeport, Conn.

Neely, James A.—Agricultural engineer, Tennessee Valley Authority. (Mail) Box 911, Jackson, Tenn.

Newsom, Jesse—Farm implement dealer, Sandersville, Ga.

O'Donnell, John F.—Junior engineer, research and development, Dearborn Motors Corp. (Mail) R. R. No. 2, Utica, Mich.

Palmer, Edward L.—Instructor in agricultural engineering, Long Island Agricultural and Technical Inst., Farmingdale, L. I., New York.

Puckett, Hoyle B.—Student in agricultural engineering, University of Georgia, Athens, Ga. (Mail) 225 W. Southview Dr.

Raynor, A. L.—General agent, Martin Steel Products Corp. (Mail) 960 College Ave., Collegeville, Pa.

Reams, Robert E.—Engineer, tractor testing lab., Allis-Chalmers Mfg. Co. (Mail) 1000 S. 76th St., West Allis, Wis.

Roberson, Perry M., Jr.—Graves Apts., 13-C, Auburn, Ala.

Scheidenhelm, E. L.—Assistant chief engineer, H. D. Hume Co., 812 N. Main St., Mendota, Ill.

Service, John W.—Sales manager, John Deere Spreader Works, East Moline, Ill.

Shager, B. J.—Product designer, research dept., International Harvester Co. (Mail) East Moline Works, East Moline, Ill.

Stewart, R. V.—Hydroagricultural representative, Georgian Bay Regional Office, Hydro-Electric Power Commission of Ontario, 84 Collier St., Barrie, Ont., Canada.

Stoneburner, Paul W.—Assistant extension specialist in farm structures, Virginia Polytechnic Institute, Blacksburg, Va.

Svoboda, Frank G.—Illinois Northern Utilities Co. (Mail) Oregon, Ill.

Tarbox, John P.—Executive engineer, The Budd Co., Philadelphia 32, Pa.

Tropeano, Joseph C.—Sales manager, Larchmont Farms Co., Lexington, Mass.

Van Syoc, Wendell M.—Student engineer, John Deere Waterloo Tractor Wks., Waterloo, Iowa. (Mail) 800 W. Mullan Ave.

Virkler, Harold E.—Director of purchasing, G.L.F. Farm Supplies, Terrace Hill, Ithaca, N. Y.

Vittetoe, Gene C.—P. O. Box 52, LaVilla, Tex.

Webb, Clifford H.—Instructor, institutional farm training. (Mail) R. R. No. 2, Hahira, Ga.

Webb, Edward B.—Student agricultural engineer, Philadelphia Electric Co., 10th and Main Sts., Coatesville, Pa.

Zimmerman, Harold P.—Special representative, tillage and seeding machines sales, International Harvester Co. (Mail) 3205 E. 50th St., Minneapolis, Minn. *(Continued on page 366)*

Profit? Yes! A man *should* farm for profit. But in farming, profit is not the entire sum of the compensation. Pride of ownership in fertile, productive fields is part of it. Pride of ownership in a finished herd of pure-breds can be another.

To some farmers also comes the downright pleasure of working their lands with OLIVER Tractors. Theirs is the sure knowledge that the world produces nothing finer . . . and thus they portray the keen discrimination which looks beyond a price tag and sees a quality unimpaired by any consideration other than service.

The new fleet of OLIVER tractors appeals so strongly to such farmers that ownership of these tractors is fast becoming a mark of success in farming.

The OLIVER Corporation 400 W. Madison Street, Chicago 6, Illinois

THE OLIVER CORPORATION

OLIVER

"FINEST IN FARM MACHINERY"

Applicants for Membership

(Continued from page 364)

TRANSFER OF GRADE

Allen, William S.—Extension agricultural engineer, A. & M. College of Texas, College Station, Tex. (Mail) Box 2237 (Junior Member to Member)

Griebeler, Wilbur L.—Assistant professor of agricultural engineering, Oregon State College, Corvallis, Ore. (Junior Member to Member)

Grout, A. Roger—Assistant county agent at large, division of agricultural extension, Pennsylvania State College. (Mail) 486½ Walnut St. Meadville, Pa. (Associate to Member)

Miller, Edwin L.—Assistant in agricultural engineering research, Purdue University, Lafayette, Ind. (Junior Member to Member)

Personnel Service Bulletin

The American Society of Agricultural Engineers conducts a Personnel Service at its headquarters office in St. Joseph, Michigan, as a clearing house (not a placement bureau) for putting agricultural engineers seeking employment or change of employment in touch with possible employers of their services, and vice versa. The service is rendered without charge, and information on how to use it will be furnished by the Society. The Society does not investigate or guarantee the representations made by parties listed. This bulletin contains the active listing of "Positions Open" and "Positions Wanted" on file at the Society's office, and information on each in the form of separate mimeographed sheets, may be had on request. "Agricultural Engineer" as used in these listings, is not intended to imply any specific level of proficiency, or registration, or license as a professional engineer.

NOTE: In this Bulletin the following listings still current and previously reported are not repeated in detail. For further information see the issue of AGRICULTURAL ENGINEERING indicated.

POSITIONS OPEN: 1947 APRIL—O-552. SEPTEMBER—O-581. DECEMBER—O-604. 1948 JANUARY—O-605, 606. APRIL—O-612, 613, 614, 615. MAY—O-617. JUNE—O-620, 621, 622, 623. JULY—O-624, 625, 626, 627, 628, 629, 630..

POSITIONS WANTED: 1947 SEPTEMBER—W-119. 1948 JANUARY—W-157. MARCH—W-146. APRIL—W-158, 159. MAY—W-166, 169, 171, 172, 173, 174, 175, 176. JUNE—W-178, 179, 181. JULY—W-183.

NEW POSITIONS OPEN

MANAGER, fertilizer mixing and acidulation plant, to take complete charge of plant operations. Location, Missouri. BS deg and at least two years of fertilizer plant supervision, including both acidulation and dry-mixing. Should have rural background, good personality, and be agreeably aggressive. Good opportunity for advancement. Age 30 - 40. Salary, undetermined but competitive. O-631

RESEARCH PROFESSOR, for full-time research in various branches of agricultural engineering, particularly farm machinery, in eastern land-grant college. MS deg in agricultural engineering, or equivalent. Varied research, application, extension, and teaching experience since graduation. Usual personal qualifications for public service research. Good opportunity for advancement. Age, 35 - 45. Salary $5400 maximum to start. Opening available Sept. 1. O-632

DESIGN ENGINEER, for development of spraying machines and special-purpose tractors, in England. All would be large and powerful machines required for use as contractors tools. BS deg or equivalent in agriculture or chemical engineering. At least 3 yr with American or Canadian firm of agricultural machinery manufacturers and at least 3 yr drawing office experience, preferably with manufacturer of spraying equipment. Must have drive, energy, and originality in design work. Possibility of promotion to chief designer or chief engineer. Age, 25 - 35. Salary, 1000 - 1800 pounds sterling. O-633

MANAGER, farm equipment division of export organization located in New York City. Requires experience in dealing in farm equipment in foreign countries and acquaintance with American manufacturers of farm equipment. Opportunities largely up to individual. Age 40 - 50. Salary open, salary plus profit-sharing basis. O-634

DESIGN ENGINEER, to prepare production designs and drawings of farm implements, in Midwest plant of large manufacturer. BS deg in agricultural engineering or equivalent and 4 or 5 yr experience in designing farm equipment. Good character references required. Opportunity for advancement excellent, as company is growing and has plants across the entire country. Older man preferred, but experience is main requirement. Salary open. O-635

AGRICULTURAL ENGINEER (assistant professor or instructor rank) for research and teaching in irrigation, farm structures, farm machinery, and rural electrification, in southwestern land-grant college. MS deg in agricultural engineering, or equivalent, and major in one of above fields. Teaching or research experience in field, particularly irrigation. Good health and personality. New department with new building under construction. Opportunity excellent for man interested in starting with new organization. Age, under 40. Salary $3000 - 3600. O-636

AGRICULTURAL ENGINEER (research associate) for research in rural electrification field in midwestern land-grant college. BS or MS deg in agricultural engineering, or equivalent. Farm background and sales, teaching, or research experience in rural electric field desirable. Neat appearance, pleasing personality, ability to work cooperatively with farm people. Position sponsored financially by private industry. Program set up initially for 4-yr period. Expanding rural electrification in state offers opportunity for advancement depending largely on individual. Annual basis with one month paid vacation. Age, 25 - 35. Salary $3000 - 3600. O-637

(Continued on page 368)

PROFESSIONAL DIRECTORY

RATES: Announcements under the heading "Professional Directory" in AGRICULTURAL ENGINEERING will be inserted at the flat rate of $1.00 per line per issue; 50 cents per line to A.S.A.E. members. Minimum charge, four-line basis. Uniform style setup. Copy must be received by first of month of publication.

PERSONNEL SERVICE BULLETIN

(Continued from page 366)

AGRICULTURAL ENGINEER (instructor) to teach farm power and machinery and soil conservation in midsouthern land-grant university. May include some research. BS or MS deg in agricultural engineering or equivalent. Desire teaching and research experience but will accept inexperienced man if necessary. Good character, adaptable, cooperative, able to teach. Opportunity to work for advanced degree while on full pay, and for advancement to professor. Age 30 - 40. Salary $3000 - 4500. O-638

NEW POSITIONS WANTED

AGRICULTURAL ENGINEER desires design, development, sales, or service with private company in power and machinery or farm structures field. BS deg in agricultural engineering, 1938, University of Illinois. Experience in farm equipment design, 3 yr; soil conservation as junior civil engineer, 2 yr; tire and tire-making equipment design and development, 4 yr; farm management in Midwest 2 yr, including design, construction, and supervision of drainage; farm buildings, grain elevators, and office buildings; and general agricultural engineering services. No disability. Available now. Married. Age 38. Salary open. W-184

AGRICULTURAL ENGINEER desires research in power and machinery field with public service agency or private company. BS deg in agriculture, 1948. Southwestern Louisiana Institute. Noncommissioned service in Army Air Force, 1942 - 1945. No disability. Available Sept. 1. Married. Age 31. Salary open. W-185

AGRICULTURAL ENGINEER desires development, research, teaching, or any combination of these duties, in soil and water field, with private company or public service. MS deg in agricultural engineering expected December, 1948, Michigan State College. Graduate assistant 5 yr; instructor 1 yr; with research in field of supplemental irrigation. War enlisted and commissioned service in naval reserve. No disability. Available Jan. 49. Married. Age 28. Salary open. W-186

AGRICULTURAL ENGINEER desires research or extension work in farm structures or soil and water field, in land-grant college, either on full-time basis or with opportunity for graduate study; or test and development of farm machinery in private industry. BS deg in agricultural engineering, 1948, Ohio State University. Experience in managing and operating 300-acre fully-mechanized general livestock and grain farm in Northwestern Ohio, 3 yr. War service in Navy as aviation electronics technicians mate. No disability. Available Sept. 1. Age 28. Salary open. W-187

AGRICULTURAL ENGINEER desires production, research, or educational work in power and machinery or soil and water field, in public service or private industry; or research or sales work in rural electrification. BS deg in agricultural engineering, 1948, University of Tennessee. Experience as dairy herd improvement supervisor, Tennessee Dairy Extension Service, one year; Navy, one year; ass't production foreman, Tennessee Eastman Corp., one year. No disability. Available Sept. 1. Married. Age 25. Salary $3000. W-188

AGRICULTURAL ENGINEER desires work in water conservation field in West or Southwest where effective work can be done at all times of the year. BL, AB, and MA degs, with special courses in drainage, hydrology, surveying, and dam and levee construction. Experience as SCS technical foreman, 3 yr; game management agent, aquatic wild life, Ohio Conservation Department, 5 yr; chief engineer, Ohio farm pond program, 5 yr; own contract business, building lakes and ponds and laying out farm drainage systems, 2 yr. Army commissioned service 1918 - 22. Subsequent service in Ohio National Guard. Slight-deafness corrected by hearing aid. Available December 1, or earlier. Married. Age 50. Salary $4000 min. W-189

AGRICULTURAL ENGINEER desires research or project engineering work in government agency, research or extension work in land-grant college, research in private company, or soil and water conservation work. BS deg in agricultural engineering, major in farm machine design, 1947, University of Georgia. Farm background. War noncommissioned service in Army Air Corps, making maps from aerial photos, and maintaining gasoline-driven power unit, 4 yr. Research on cotton mechanization, 7 mo. Nervous disability, 10 per cent. Available within 30 days. Married. Age 28. Salary $3000 min. W-190